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# CAMOUFLAGE PRACTICES

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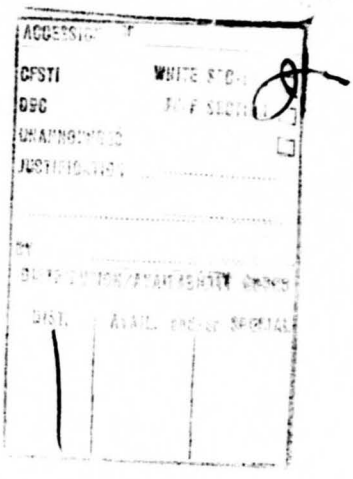

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## ABSTRACT

Results are presented of a survey of the state of the art of camouflage, comprising examination of literature on the subject and interviews with persons working in the field. The practice of camouflage is reviewed under seven headings: principles, location and natural cover, artificial cover, camouflage paints and coatings, decoys, fieldworks, and smoke. The report includes a list of applicable military specifications, abstracts of selected specifications, and has a comprehensive bibliography.

## FOREWORD

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This technical report has been reviewed and is approved.

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# CHAPTER 1

## PREFACE

1.1 Introduction. This report is an account of the state of the art of camouflage as ascertained from examination of literature on the subject and interviews with persons working in the field. No claim is made as to completeness, nor does the author pretend that all the techniques and materials herein described reflect the latest developments in the field.

1.2. Scope. This report stresses the technical aspect of camouflage practices. Camouflage principles and doctrine, an understanding of which is essential to the correct exploitation of camouflage procedures and materials, are presented in enough detail to provide a background for the more extensive details of application. Army Field Manual FM 5-20, Camouflage, Basic Principles and Field Camouflage, affords a clear (though not thorough) exposition of camouflage principles used by the Army. The reader will find other treatments of this subject cited in the list of references (Reference 1 through 3).

# CHAPTER 2

## CAMOUFLAGE PRINCIPLES

2.1. Introduction. Camouflage is a form of counterintelligence. It is the exploitation of environment and matériel for the purpose of misleading an adversary. Camouflage is devised to thwart two kinds of enemy operations: reconnaissance and attack. The camoufleur's work is directed primarily toward the enemy's intelligence and command functions -- toward making them draw incorrect inferences as to the operations he wishes to conceal. If he is successful, the operations either go completely undetected or are mistaken as to character, mission, or size. When camouflage fails to deceive the enemy command, it can weaken his attack by causing confusion, delay, or waste of ammunition.

Technological advances in reconnaissance and weaponry complicate the tasks of camouflage research and development. Doctrine (the body of opinion concerning the application of principles) changes with technology, sometimes slowly, sometimes abruptly. But the principles (the body of observations and generalizations underlying a study) change hardly at all.

The study of camouflage begins with a consideration of observation.

2.2. Direct and Indirect Observation. Observation can be either direct (personal) or indirect (e.g, photographic).

The principal advantages of direct observation are that the observer can readily see movement of troops or equipment, and that observation can be sustained over long periods of time. The main disadvantages of direct observation lies in human fallibility: what the observer sees is affected by his physical and mental condition and by his prejudices and training.

Indirect observation is carried on with the aid of permanent records (like photographs); it is far reaching, covers large areas, and can be very accurate.

The picture can be studied in comparative leisure. The principal disadvantage in indirect observation is that as the record covers a very short period of time movement is difficult to detect.

Photography can also exploit the near infrared region of the electromagnetic spectrum, particularly in the detection of camouflage. This does not mean that the principles of camouflage have changed, but rather that the tasks of camouflage research and development are all the greater.

For detailed information on reconnaissance photography the reader is referred to Army Technical Manuals TM 30-245, Photographic Interpretation Handbook (NAVWEPS 10-35-610; AFM 200-50: 1954) and TM 30-246, Tactical Interpretation of Air Photos.

2.3. The Factors of Recognition. Detection and recognition are effects of combinations of the seven factors of recognition: position, shape, shadow, texture, color, motion, and shine.

2.3.1. Position. An object, even a "camouflaged" object, may be detected if it, or its camouflage, is out of place. A quonset hut is almost everywhere likely to be an object of suspicion. On the other hand, objects can be detected if they are in their proper place. A sophisticated enemy must be expect to have a working knowledge of all the military arts: he knows where to look for airfields and other large installations, and for bivouacs, command posts, artillery emplacements, and so on.

2.3.2. Shape. Military works and equipment have characteristic shapes. The presence and even the nature of a military force can be ascertained through detection of these shapes. Moreover, the works of man in general display a certain regularity, both as to shape and as to disposition. So the enemy also searches for round and square objects, and so on, and for things arranged in order.

2.3.3. Shadow is one of the most revealing of the factors of recognition. For it usually provides more contrast with the surroundings than does the object that casts it,

while adding to the ground area taken up by the object and betraying details of elevation and shape.

2.3.4. Texture refers to the amount of detail in a surface. A smooth surface has a light-reflectivity that varies considerably with the relative positions of the sun and the observer. A rough surface, because it reflects light in all directions, will exhibit a more uniform reflectivity. Foliage and standing grass usually show up dark in photographs. For much light penetrates to the ground, and of that part which is reflected only a very small fraction gets to the observer.

2.3.5. Color. The three characteristics of color are hue, tone (value), and saturation. Hue is that property according to which we distinguish a color as red, green, etc. Tone is an indication of the brightness of a color. And saturation is a color's freedom or degree of freedom from admixture with white. Hue and saturation are often for convenience combined under the term chroma. Objects can be detected by the contrast between their color and that of their surroundings. Contrasts in tone are the most conspicuous from a distance of a few hundred feet and beyond; and as the observer comes closer, hue increases in importance. Texture manifests itself as a darkness in tone. References 4 through 6 contain information in varying degrees of detail, on the specification of color.

2.3.6. Motion is the strongest factor in attracting attention . The eye is very quick to notice any movement in an otherwise still scene. The aerial camera can record the fact that something has moved when two photographs of the same area are taken at different times. If an object has moved, the changed position is apparent when the two photographs are compared.

2.3.7. Shine is a particularly revealing signal to an observer. Whenever light strikes a smooth surface, such as a wind-shield, headlights, mess gear, or a person's face, light may be reflected directly into the observer's eye or the camera's lens with striking emphasis.

2.4. Recognition Features. The camoufleur should be familiar with the factors of recognition, which were presented in the last section. This classification is useful in that every camouflage problem can be analyzed in terms of these factors. But such classifications, however ingenious and however useful in their own way, suffer from being irrelevant from other points of view. For instance, it is one thing to know that foot-paths are conspicuous from afar because of contrast in tone. It is quite another thing to know that foot-paths can be a dead giveaway of an otherwise perfect job of camouflage. An account of recognition features should complement the foregoing account of factors of recognition. The following four paragraphs provide instances of the kind of information such an account should provide.

Regularity or Irregularity of Disposition When Inappropriate. Regularity in the disposition of things is a characteristic of the works of man. Because of their rarity in open terrain, large objects disposed in neat rows are conspicuous. Moreover, they make good targets for enfilading fire. On the other hand, failure to dispose objects so as to imitate the regular patterns of densely settled areas can lead to their discovery -- again through the contrast of the novel among the commonplace.

Alien Configurations attract attention. Cylindrical and spherical fuel tanks, for instance, are among the first things noticed in aerial photographs of cities. Now fuel tanks are not alien to cities, but their rarity makes them conspicuous: the form is alien to the pattern of blocks and buildings. In the countryside, continuous lines, regular figures, solid shapes, and unrelieved surfaces are conspicuous because such are not ordinarily found there. A road, a path, the edge of a long shed, a roof -- all are quickly noticed because they contrast with their surroundings.

Tracks -- their presence or absence, their density, configuration, bearing -- are of great importance to the photo interpreter when he has little else to go on.

When the tracks of a vehicle are distinct, the photo interpreter can often tell -- from their width, their depth, and the way they turn -- what kind of vehicle -- whether tank, truck, or half-track -- made the tracks. Important facts concerning the strength and mission of the force can be inferred from the study of these tracks.

Open Entrances and Firing Ports are particularly conspicuous because of the very deep shadows they cast. They are readily picked out in photographs, and a large, gaping entrance (to a repair shop, for example) may be conspicuous even to a casual observer.

Other recognition features that could be described are tonal contrast, height, shadows, the clump or mound effect, position, drainage ditches, power lines, trenches, the scarring of the ground, spoil, debris, incomplete decoys, landmarks, the absence of signs of activity in decoy sites, blast marks, and the absence of access roads to decoy sites.

2.5. Functional and Corrective Camouflage. It is useful to distinguish two kinds of camouflage: functional and corrective. Functional camouflage is camouflage integrated into an operation. A few instances are restricting traffic to roads and paths that follow natural boundaries (like rivers and hedgerows), dispersion, defilade, and avoidance of regularity (where appropriate). Corrective camouflage denotes all other measures taken to diminish the visibility of objects otherwise detectable.

The distinction between the two kinds of camouflage is illustrated by the instance of a truck parked under a large tree (functional) and covered over with nets and broken foliage (corrective).

Functional camouflage is loosely described as doing what you must do anyway in such a way as to improve concealment. Corrective camouflage tends to add to the logistical and maintenance burdens of an operation.

2.6. The Four Basic Methods of Camouflage. Every camouflage measure can be regarded as one or more applications of the four basic methods: hiding, blending in, deception, and distraction.

2.6.1. Hiding hardly requires explication. Men and stores can be hidden in caves and sub-surface shelters. Aircraft are hidden from ground observation by revetments. A lot of things can be hidden by smoke. Defilade is a mode of hiding long in use.

2.6.2. Blending In. The purpose of blending in is to achieve an effect of harmony with the surroundings.

The first consideration in any camouflage plan is positioning: the disposition of forces, in the aggregate and in detail, to take advantage of concealment afforded by the terrain. The camoufleur takes advantage of shadow cast by foliage and irregularities in the ground. He chooses sites near established roads and paths and sets up turn-offs where they will not be conspicuous. The establishment of new roads and paths is discouraged, except when necessary, and these are to be limited to natural boundaries, like streams and gullies. (The same can be said for power lines and the like.) He also takes advantage of defilade. Because things grouped together can draw attention to themselves, men and matériel must be dispersed. (Dispersion also lessens the effectiveness of enemy fire.) Regularity in the disposition of things should be avoided where inappropriate (as in open terrain) and adopted where appropriate (as in cities). The neighborhood of a conspicuous landmark is to be shunned, except perhaps for transient use, since such landmarks are used in air attack for determining your exact location when reconnaissance photographs are available.

2.6.3. Deception. A hangar disguised as a barn is an instance of deception. The emphasis in this form of deception is on avoiding recognition, rather than on escaping detection. The other form of deception is the use of decoys. In this case an object of no value is made to look like a valuable one.

2.6.4. Distraction. Means which cause the enemy to direct his attention or fire away from proper targets are instances of distraction. Though not effective against reconnaissance, distraction by flashing lights and dazzling patterns can severely tax the limited time available in the airborne attack mode.

2.7. Camouflage Discipline is the strict observance, by everybody, of all measures necessary to conceal an operation. These measures range from seemingly petty prohibitions -- as for instance against talking after dark -- to limiting traffic by guide wires along paths (to prevent widening) and careful attention to maintenance.

"Camouflage discipline means the difference between success and failure in concealment... It begins with reconnaissance and ends only when the position is abandoned... Choice of camouflaged material is of less importance than discipline and choice of position." (Reference 7)

# CHAPTER 3

## LOCATION AND NATURAL COVER

3.1. Introduction. The relationship between Location and Natural Cover necessitates the combination of them into one chapter. Location is the most important single camouflage measure. Natural cover is to be preferred over artificial cover because of its effectiveness and the easing of supply and maintenance burdens.

3.2. General Considerations in Location. The suitability of a place as the site for an installation depends upon how it satisfies a number of varied considerations, which can all be subsumed under four categories: mission, active defense, communications, and passive defense.

Under mission we include all those "technical" considerations which concern the suitability of the site for the carrying out of the primary tasks of the installation -- including, in the case of an air base, position of the enemy, topography, obstructions, drainage, hydrological conditions (like rainfall and the water table), ground cover, and prevailing winds.

The active defense employs patrols, artillery, fighter-intercept planes, and suchlike.

Communications is used here in its conventional military sense: the "stream of supplies and reinforcement." (Reference 8) The accessibility of a site is part of its communications. "Communications dominates warfare." (Reference 9).

Under passive defense we include the "new" art of camouflage along with longer-established measures, such as dispersion and defilade. The use of fences, barbed wire, ditches, and perimeter guards are other measures in passive defense, but they are normally considered separately, as base security.

3.3 Camouflage of the Air Base Location. It is not to be expected that an installation as large as an air base will go undetected for long. It is naive to expect camouflage to confer on an operation some kind of permanent invisibility. Camouflage can delay detection, it can divert attack, or it can frustrate an attack under way. And even the last of these can be well worth the "investment" in camouflage. An attacking force is not likely to have the means or the comparative leisure of the reconnaissance pilot or the photo-interpreter, so that camouflage deemed inadequate against the latter may be quite satisfactory against the former. The problem, that is to say, is far from hopeless even in the face of the latest detection devices.

The camouflage of any location has two inter-connected aspects: (1) site selection, the question of where to set up the installation, and (2) the placement of the components of the installation. Their connection lies in the fact that one of the most important considerations involved in site selection is the availability of cover, and the utilization of cover is part of the problem of placement.

3.3.1. Location Selection is a high-echelon responsibility Those experienced camoufleurs who have written on this phase of their work insist that the choosing of the site is often the most important single camouflage measure - - that if the site is well chosen, most other camouflage measures can be regarded as supplementary, and that no amount of elaborate work can compensate for an ill-chosen site.

The following paragraphs describe the considerations that make for good site selection.

3.3.1.a. The Availability of Natural Cover Within the Site. Here "cover" means any feature of the land that can be exploited as camouflage, including the shadow cast into natural depressions in the ground, the spotting of the ground by boulders or large shrubs, the shade of trees, and buildings. The exploitation of natural cover is treated in detail in later sections.

3.3.1.b. Landmarks. The neighborhood of a landmark is to be shunned. Landmarks are used by aviators in dead reckoning for spotting pre-assigned targets. A landmark can be a lake or a pond, an inlet, a bend in a river, a conspicuous structure, a road junction, a railroad, an unusual terrain feature -- anything conspicuous enough to serve as a point of reference for a pilot or even for a land force. Moreover, the eye is involuntarily drawn toward some landmarks, so that things in their neighborhood are open to detection.

Sometimes the neighborhood of a landmark can not be shunned. If the situation allows, the landmark itself can be camouflaged and a dummy landmark set up elsewhere. The most celebrated job of landmark camouflage is that done by the Germans to the harbor of Wilhelmshaven in World War II. The harbor was a long inlet of the sea -- squared off at the inner end and about 1200 feet across there. A highway and railway crossing about 2000 feet from this end created a distinct, recognizable, roughly rectangular enclosure. Allied bombardiers were presumably instructed to find their targets by their relationship to this enclosed end of the harbor. This the Germans expected. So they covered the enclosed end with canvas-covered floats painted to look like city blocks from above. About 2000 feet below the bridge a dummy bridge was laid across the harbor parallel to the real one. Thus the enclosed part of the harbor was made to look like land, and the next 2000 feet was made to look like the enclosed part. Other important landmarks in the port city were also camouflaged. The Germans' intent in this ambitious work was to mislead Allied bombardiers into bombing targets of no strategic value.

3.3.1.c. Turn-Offs. Good roads are necessary for an installation if it is to be accessible by land. This fact is well appreciated by enemy intelligence as well as by those who plan installations. An installation may be otherwise perfectly camouflaged, but a new turn-off or a road that seems to go nowhere will arouse suspicion. For this reason road or rail turn-offs must be hidden. This is usually accomplished by making turn-offs into wooded areas. If the turn-off itself cannot be hidden the road must be continued to some likely, innocuous destination.

3.3.2. Placement. Once the site is chosen for an installation, the camoufleur's task becomes that of making the most of what opportunity remains for camouflaging its elements, and siting is the most valuable measure he can apply to this task.

3.3.2.a. Interior Roads and Paths are necessary for the operation of an installation. The prominence of roads and foot paths, and what may be inferred from their shape, bearing, and intensity, are treated in the chapter on decoys. The track made across a clearing by one man or one truck is not likely to attract the attention of a combat or patrol mission, although the photo-interpreter searches for such signs. But the scarring of the ground due to frequent use can be obvious to even the most casual observer. Therefore a location is desired which has a network of internal roads already developed, or where internal traffic can pass without leaving obvious tracks -- as along streams and hedgerows, through gullies, and cliffs, over rocks, etc. New roads or paths are to be made across open space only after the advantage and disadvantage of such expedients are weighed.

It might be asked, here and elsewhere, Why bother with such details as roads and other internal features when the landing strip of an air base is such a dead giveaway? There are two answers to this question: (1) No-one has proven that landing strips cannot be camouflaged. And even if such should be deemed impossible today, who is to say that it won't be possible tomorrow? (2) It should not be forgotten that it is a function of camouflage to protect men and equipment during attack as well as to avert attack. If enough can be saved from an attack, a crippled air base may be in no worse a position than was Washington at Valley Forge and Morristown.

3.3.2.b. Waste and Spoil. The site should offer means for the quick disposal or temporary storage of waste and spoil: places in shadow much of the day, like gullies, caves, ravines, and about the trunks or trees; lakes or water-courses large enough to contain or wash down matter sunk in them.

3.3.2.c. Dispersion is taken as a method in camouflage because things are usually much more difficult to detect when dispersed than when grouped together. Of equal importance with this virtue is the simple fast, inherent in the nature of things, that part of the force of an assult is dissipated in the spaces between men, machines, or stores. The extent to which an operation is dispersed depends upon operations requirements, among other things. The smaller an installation, the less likely it will be detected. But it seems futile to try to make an air base compact enough to make any difference in its detectability. Moreover, compactness may work against dispersion.

3.3.2.d. Defilade is the protection against ground observation and flat-trajectory fire afforded by such obstacles as hills, ridges, banks, and works. Two examples of works are trenches and "revetments." Strictly speaking, a revetment is a support for a vertical or nearly vertical earth bank, but the term often loosely applied to any incomplete enclosure (not necessarily roofed) usually built to protect its interior from blast and small-arms fire.

3.3.2.e. Shade. The camoufleur should realize that from his point of view there are two kinds of shade: the (more or less) permanent and the shifting. The shade in a forest or a small wood changes little during the day. But the shadow cast by a wall or by a few trees shifts as the sun moves across the sky. The "permanent" shade is of course of greater value to the camoufleur than the shifting, but he may be able to make judicious use of the latter. How he utilizes the shifting shade depends largely on his evaluation of the tactical situation. For instance, the installation may be in greatest danger of attack when visibility is best. If this is during late morning, when the sun is in the south and east (in the Northern Hemisphere), then the north and west sides of walls and trees will be best for hiding things in their shadow.

Objects that are not hidden in the shade can be detected and recognized by their shadows, even when toned down themselves. But if he cannot hide something in the shade, the camoufleur may at least be able to place it so that its shadow is cast on a broken surface, thereby breaking up up the shadow itself, or the surface (upon which the shadow falls) can be broken up. The unevenness of the ground may be enough to break up shadow. If not, clumps of bushes or

patches of grass can be planted for that purpose. Things should not be placed so that their shadows fall across roads or other light surfaces.

3.3.2.f. Pattern. The eye is attracted by contrasts in arrangement: by order in the midst of disorder, by disorder in the midst of order: by rows of neatly stacked supplies in a wilderness, by a junk-yard within a metropolis.

3.3.3. Nature of the Terrain. The disposition of the elements of an installation should partake of the nature of their surroundings. One of the first questions to be asked in the planning of camouflage should be, What is the nature of the monotony of terrain of this locale, and how can we exploit it? Because the nature of the terrain figures large in a camoufleur's thoughts, the treatment of this aspect of placement will be presented according to terrain type under six headings: barren, verdant, bosky, sylvan, rural, and urban.

3.3.3.a. Barren really means utterly unproductive, but we will take it here to signify not only terrain which is sterile but also that whose growth holds out little promise for the camoufleur. (A clump of palm trees on the Sahara induces pleasure for the tourist but invites scrutiny from the photo interpreter.) Barren land may be with or without significant topographical detail.

Barren regions devoid of significant topographical detail are rare, and unless camouflage is prepared especially for an operation in such a region, the camoufleur may just have to make the best of a bad job. In a flat or gently undulating unbroken snow-field or sand desert, dispersion and defilade are the only placement measures the camoufleur can employ. If he can drape the dispersed elements with white covers, taking care to suppress shadow, the camouflage can be quite effective. If he does not have such cover, dispersion will at least keep a bad situation from becoming worse. There are other expedients available to the camoufleur: he can set up a decoy installation elsewhere, and he can "pad" the real installation with dummies, in expectation that the enemy will expend some of his ammunition on them. But decoys, whether of single components or of a whole installation, under such conditions may add to the detectability of the operation. The decision to set them up would have to wait upon an evaluation of the over-all tactical situation.

A flat gently undulating sand-desert would present much the same problems as the snow-field.

With significant topographical detail the way is open for the exploitation of shade. Outside of the polar regions, snow-fields are generally abounding in shadows and bare spots. Dispersion is still a most useful measure, but the extent to which an installation is dispersed depends upon the disposition of such natural cover, as well as upon operational requirements. Sometimes, the lay of the land may even suggest a kind of order. For instance, buildings can be aligned parallel to the contour lines of a terraced hillside. This is an instance of <u>following terrain lines</u>.

3.3.3.b. <u>Verdant</u> we use in a limited sense of being covered with grass and plants too small to cast shadows suitable for concealment of shelters or large equipment. The great grasslands of the temperate zones are examples of this kind of terrain, as is the tundra of the north. Verdant terrain, even where flat, is not necessarily uniform in color, and of course the more varied it is, the easier is the task of the camoufleur. But what strikes the novice is the darkness of standing grass as viewed from far above. When seen from the side or from a low elevation, the grass is bright green. This is due to the diffuse reflection of skylight or sunlight off a myriad blades of grass. The blades are more or less vertical and reflect the light downward, sideways, and only slightly upward, except when they become top-heavy and bend over appreciably, or where they are pressed down by traffic. Hardly any light is reflected aloft, and this is why standing grass appears from above much darker than trees nearby -- so dark, in fact, that partly for this reason more attention is paid to tone than to chroma in the development of artificial camouflage cover. So with this natural darkness of standing grass as viewed from above, perhaps abetted by a mottling effect produced by unevenness in the ground or patchiness of the vegetation, as in tundra, the camoufleur, if he has to, can place objects in the open with justifiable hopes of surviving much casual and even some precise observation. Placement should be determined by the opportunities afforded by the terrain, and this usually means eschewing regularity.

3.3.3.c. <u>Bosky</u>. A bosk is a thicket or a small wood. The land is still for the most part open, but there are enough trees to provide more than occasional natural cover, and there must be enough all around to make scrutiny tedious to the air

observer. Farmlands may fit this description. This is probably the best terrain for camouflaging an air base, for there is enough open space for a landing field to make the task of searching for it also tedious.

The distribution of trees will probably not suggest any kind of pattern, although there is a segregation among kinds depending upon the elevation, the nature of the soil, the height of the water table, and so on. Elsewhere the trees may grow along boundaries, as in farmlands. Where the trees or coppices are dotted, seemingly at random, over the ground, so likewise should shelters and equipment be placed, if natural cover is not available. Where the trees are strung out in lines, anything placed out in the open would be conspicuous.

3.3.3.d. Sylvan means heavily forested. In this case there is natural cover practically everywhere. The landing field may prove difficult to conceal if the large open spaces are few enough to admit of frequent inspection by the enemy.

3.3.3.e. Rural areas contain ample open land for the landing field, and often no dearth of natural cover, but the presence of houses and other man-made shelter offers additional opportunity for concealment. Native-built shelters already on the site are to be preferred over anything we can build -- if they are suitable -- for three reasons: (1) There is a saving of time, labor, and materials. (2) Native-built houses are of greater "fidelity" as camouflage. (3) The suspicions of the enemy will not be aroused, as they might be by the appearance overnight of new houses.

If new local-type shelters are to be built, their arrangement must be considered. For instance, in a land where everybody lives in hamlets or villages, a lone dwelling could arouse suspicion. Such hamlets may only stand along highroads, or on the banks of navigable waters. so that a cluster of huts set up elsewhere would be suspected.

3.3.3.f. Urban. We will take urban to signify any area dominated by the network of streets typical of large communities. This network of streets is usually rectangular in new cities and in the newer sections of older cities. The rectangular pattern, though preponderant, may be broken up by old or new highways, rivers, parks, and hills. Even in the crowded tenement areas, there is good order in the arrangement

of buildings. In older cities, large sections are threaded by a maze of streets and alleyways that appears often random. The buildings are usually jammed together along these streets.

With the use of paint, cloth, and panelling the camoufleur can disguise air-base shelters set up in urban areas so as to resemble local-type structures. But even without such useful measures he should site them in a way harmonious with the local pattern of buildings.

3.4. Natural Cover. There are four kinds of natural cover other than caves and the like: defilade, night, shade, and vegetation. Defilade and night are used for hiding. Shade and vegetation are exploited in hiding and blending in, the latter usually through disruption of outline.

3.4.1. Defilade has already been considered in connection with placement. It provides some cover against low-flying airplanes, but its chief strength is also its chief weakness. It enables aircraft, or other targets valuable to the enemy, to be protected when placed in a straight line. The disadvantage comes when the enemy realizes this pattern and strafes the area or sets artillery for this pattern.

3.4.2. Night. The dark of night is a form of natural camouflage that has been exploited for ages. But a false sense of security is apt to encourage breaches of camouflage discipline. So the enemy can wait, also in the darkness, for signs of such breaches, and aerial photographs taken at night can expose them.

3.4.2.a. Light Discipline. A light can be detected farther away at night than in daylight. This is so because the dark night-background provides suitable contrast for the light and because there is usually little else in the neighborhood to distract the eye. Light discipline is by far the most important phase of night discipline. Work lights are to be shielded by using them in light-proof shelters. Outside light is to be used only when necessary. Not only can the light be detected from afar, but every time a match is lit or a flashlight used, the eyes must go through the complete process of dark-adaptation, requiring 30 minutes even on the darkest nights. The user of the light risks not only his security but also his ability to defend himself in the dark. The glow of a lighted cigarette may seem too weak to be of any importance. But much of that light is reflected forward off the

smoker's face. The skin is of suprisingly high reflectivity. Morecver, the glow of the cigarette itself intensifies, often to white heat, when you draw on it.

3.4.2.b. Sound Discipline is always important but more so at night because the air is then much less turbulent than in the daytime, so that there is less agitated air to dissipate the sound.

Sound is repressed through attention to precautionary measures. There should be no loud orders, talking, calling, or sneezing. Soft surfaces should be used for walking; soft ground should be preferred for digging. Signs or hand signals should be used when possible. Equipment should be padded and fastened so as to prevent their banging. Loading and unloading of vehicles must be done in silence; every piece should be carefully lifted and gently set down; and straw, wood shavings, or other sound absorbent material should be used for packing. It may become necessary to disconnect vehicle horns and shut off engines. The noise of engines in operation can be drowned out by other noises, due to actual operations or created by simulators.

3.4.3. Shade is comparative obscurity owing to exclusion of light. A shadow is a region of shade belonging to some object. The utilization of shade is described in Sub-Section 3.3.2.e. Material presented there and elsewhere in this handbook can be recapitulated as follows:

a. Shadow is an important factor in the detection and recognition of the things tnat cast them.

b. The shaded parts of objects are disguised primarily by disrupting their outlines with nets, covers, foilage, and such. Countershading may be applied to under-surfaces.

c. Shadows are broken up when they fall on broken ground and when they are intercepted by trees, boulders, and other large objects, which may be put in the way for that purpose.

d. Objects can be hid or their outline disrupted by putting them completely or partly in the shade.

e. The shifting of shadows in the course of the day must be taken into account.

In the Northern Hemisphere, shadows always fall to the north in the winter; in the spring and fall, to the north practically all day. In the summertime and north of the Tropic of Cancer (22.5° N latitude), shadows fall to the north only in the forenoon and early afternoon, the period being longer the farther north you are. Between the Tropic of Cancer and the Equator, the summertime shadow never falls to the north.

In the Southern Hemisphere, shadows always fall to the south in winter; in the spring and fall, practically all day. In the summertime and south of the Tropic of Capricorn (22.5° S latitude), the shadows fall to the south only in the forenoon and early afternoon, the period being longer the farther south you are. Between the Tropic of Cancer and the Equator the summertime shadow never falls to the south.

An upright pole casts a shadow on level ground of length equal to its height times and cotangent of the sun's elevation (its angular height above the horizon). Thus when the sun is halfway to the zenith (elevation 45°), the shadow is just as long as the pole. When the sun is at 5°10' elevation, shadow is about eleven times height. At lower elevations the sun throws no shadow (as the sun is no brighter than the sky), so a pole's shadow on level ground can never be more than eleven times its length. But before the shadow gets this long, it is probably too weak to matter much. (Reference 10).

3.4.4. Vegetation. Siting under trees and bushes has been dealth with elsewhere. Three other practices involving vegetation require notice: conservation, planting, and the use of cut vegetation.

3.4.4.a. Conservation. The temptation is great to clear an area completely preliminary to building on it. Certainly, runways, shoulders, and clear zones are supposed to be cleared, and obstructions above the approach angle should be removed. But the needless removal of trees, bushes and grass from the other areas of an installation is wasteful of labor and equipment and may dispose the soil to erosion.

The effect of such a practice on morale should also be considered. Moreover, living and work areas are thus exposed

to attack from around and above. Unless areas need to be cleared to provide security against infiltration or the spread of fire, only as much of the vegetation at a site should be removed as is deemed necessary for protection and operation of the installation.

A little care in locating equipment, tents, and small shelters will preclude much damage to natural growth. But where land has to be cleared for a building, the buiding can often be sited and oriented so as to preserve vegetation. Trees and bushes can be left standing right up to the base line. An instance has been reported in which a building wall was interrupted to preserve a large old tree whose broad canopy of leaves would contribute significantly to the building's camouflage.

Some knowledge of the proper treatment of natural growth trees in particular, would be useful to the camoufleur. He might at least be able to discourage mistreatment. One kind of mistreatment is the girding of trees, encircling of the trunk with tightly fastened rope, chain, or metal bands, to use the tree as an anchor. This inhibits the circulation of sap in the cambium layer, the living tissue just under the bark, and may kill the tree. Further, the cambium layer "breathes" through the bark, which is porous. Painting any extensive area of bark can kill or weaken the tree through asphyxiation of parts of the cambium layer. A seriously damaged tree can be noted within a few days of its injury and may become a liability - - worse than having no tree at all.

3.4.4.b. Planting. The planting of trees and bushes to break up shadow and disrupt outline has already been mentioned. In the latter use the effect is achieved two ways: by hiding under foliage parts of the outline or surface to be disrupted and by producing a suggestion of irregularity through planting along walls.

3.4.4.c. Cut Vegetation is used for hiding, blending in, and disruption of outline. The usefulness of foliage (leafage), however, is limited in that foliage begins to wilt within a few hours of being cut. Drying out causes the edges of the leaves to turn up, exposing the lighter under-surfaces. So a canopy of carefully placed foliage eventually takes on a lighter tone than the live foliage around. Moreover, with the cessation of vital processes, the infrared reflectance of the cut foliage, initially high,

decreases markedly. Cut foliage is useful in situations where the enemy must rely on direct observation and the cover can be changed or kept fresh. It will stay fresh longer if it is kept moist or is frequently moistened. Closing up the bottoms of stalks, with shellac, glue, mud, or anything else that will thicken or congeal in a few minutes, may slow escape of moisture. Evergreens and the hardy species of broad-leaved trees (like spruce, pine, cedar, fir, oak, and beech) are to be preferred over other kinds of trees; maple and the small- or narrow-leaved types (like aspen, willow, ash, and locust) should be used for garnishing only as a last resource. Bare branches can be used for garnishing; although such garnishing does not afford the same kind of covering as does foliage, at least it will not wilt, and its infrared reflectance will not change.

Vegetation should be taken from places where its absence will not be noticed. The camouflage plan should not call for so much cut vegetation as to cause marked alteration in the appearance of the neighborhood. The topmost branches of trees should not be chosen for garnishing, as their absence may be noticed from above. The largest branches should be let alone if the tree is to be preserved. Less vegetation is needed for disruption of outline than for hiding.

## CHAPTER 4

## ARTIFICIAL COVER

4.1. Introduction. The use of artificial cover adds maintenance and logistical burdens to an operation. Natural cover is superior in these, as well as in other, respects. But natural cover must in the first place be available before it can be availed of. In some operations--in flat, barren, for instance-- there is very little natural cover. In such cases artificial cover is more important. But even where it is not, it is useful in supplementing other camouflage.

There are two common kinds of camouflage cover: nets and solid cloth. Most camouflage nets are garnished when used. Both kinds of cover are utilized for hiding, screening, and disruption of outline. These effects are achieved by such means as impending the passage of light, changing the texture of surfaces,and presenting irregular shapes.

Other kinds of artificial camouflage cover include structures and debris. Local-style roofs erected over piles of stores can be effective against aerial observation. The debris and rubble of war have often been used to disguise emplacements. There are instances of tents made to look like garbage dumps by being covered with empty tin cans or refuse.

Army Field Manual FM 5-22 should be one of the camoufleur's most important references. It goes into considerable detail in describing the design and use of camouflage, and even provides formulas and procedures for such things as weaving nets and setting up dye-works in the field.

4.2. Camouflage Nets. The standard camoufalge nets consist of cotton-twine or steel netting garnished with cloth strips, feathers, glass fiber, or steel wool, suitably dyed or painted. The garnishing schemes and the techniques of weaving them into the nets are described in Army Field Manual FM 5-22 (Camouflage Materials).

4.2.a. Drape Nets are not intended to be draped over the things they are to hide, but are supported above them by poles or by interlocking metal struts which come with the set. Nets (or covers) draped over the objects themselves may give them away by failing to break up their outlines and

shadows. Of course, a camouflage net thrown over a piece of equipment may often be better than no net at all, but the full potential of a net so used goes unrealized, in that the unsuppressed outlines and shadows of the equipment so hid may yet give it away.

The garnishing scheme for drape nets is different from that for flat-top nets. The central 100%-covered portion is greater than that for the flat-top net, covering most of the net, and the density of garnishing (fraction of meshes covered) diminishes more or less uniformly outward. The effect of irregularity (making for disruption of outline) is produced when the net is draped.

Each drape net set has quick-opening embrasures which bisect the length and in some cases the width of the set. Intended primarily for use with artillery, the embrasure permits the nets to be quickly dropped or partially opened, along the lines where the nets are joined, to facilitate operation of the weapon.

Appendix II of Army Field Manual FM 5-20 (Camouflage Etc.) presents rules of thumb and a lengthy table for determination of the sizes of drape nets to be used with all sorts of equipment.

4.2.b. Flat-Top Nets. In World War II it was deemed unnecessary to issue flat-top nets. It was felt that a tactical installation would not as a rule be used long enough to warrant providing flat-top net sets for them. It would not be difficult, however, to set one up. A wire frame may be sufficient for support.

One advantage in the use of the flat-top net is that you can move around freely under it. Normally the net should be 1 1/2 to 2 feet above the top of the object to be concealed. The net has to be kept taut, for a sagging net can be detected through a characteristic pattern of shadows cast into the depressions formed between the supporting wires. It must be parallel with the ground. On a hillside it is to follow the slope of the hill.

The flat-top net or net set is garnished so that the center ninth (1/9th) is 100% covered -- all the meshes are woven with garnishing. From this center the garnishing is gradually thinned out (fewer meshes are covered), to form an irregular scheme. The object to be camouflaged is placed

under the center of the net, and disruption of outline is achieved through the irregularity of the garnishing scheme.

Flat-top nets are ineffective against observation from the side and can be detected in oblique photography. But flat-top nets are superior to drape nets against observation from above.

Flat nets have been used for camouflaging great areas -- areas much greater than those contemplated for the standard-size net sets. But there is no standard practice for garnishing such nets. A camoufleur familiar with the principles of his art may be able to devise an effective scheme. He can even grow an ivy covering on the net by suspending from the net, at suitable intervals, #10 cans containing ivy planted in soil. But a large, flat surface would probably have to be broken up anyway. Dummy houses, papier maché rocks, or steel-wool trees could be used, or the net can be laid around real trees.

4.2.c. Other Kinds of Camouflage Net. Specifications are in force for camouflage nets using feathers, steel wool, and glass fiber. Army Field Manual FM 5-22 (Camouflage Materials) contains sections that prescribe methods for garnishing nets in the field with feathers, steel wool, glass fiber, and tin cans.

The multipurpose net (Net, Multipurpose, specifications MIL-N43181 (2), 1966) is intended to meet the requirements of Special Warfare units, as a hammock, camouflage net, carrier for bulky loads, litter, or for catching game or fish. The net is not garnished but is made from multifilament nylon yarn, knit with a mesh size of 9/16" X 9/16" (inside measurements) and dyed olive green. As currently specified this net is about 56 inches wide and at least 108 long.

4.3. Cloth can be used for screening as well as for cover. Screens have been used not so much to withhold the fact of activity as to conceal its details. For instance, if a great stretch of road is screened from the side, the enemy on the ground would waste ammunition trying to hit single vehicles or even convoys.

The camoufleurs of World War I made extensive use of burlap and Osnaburg. Burlap is a cloth made from a coarse vegetable fiber. Department of Defense specifications call

for the use of jute or kenaf in the manufacture of burlap. Jute is the bast fiber obtained from an East Indian plant, genus Corchorus, of the linden family. Kenaf is the bast fiber obtained from the East Indian ambary plant, Hibiscus cannabinus, of the mallow family. (The words ambary and kenaf are often used interchangeably.)

The open mesh of both burlap and Osnaburg preclude long use as cover against the elements. But this same open mesh lends a roughness of texture to both kinds of cloth. Specifications are in force (MIL-C-765B (4)) for burlap and Osnaburg "impregnated" with camouflage colors and treated with flame-resistance chemicals. The reader is referred the chapter on selected specifications for abstracts of these specifications and others for cloth protective covers.

Cloth can be draped over things to be camouflaged much the same way drape nets are: supported above them with sticks or poles so as to disrupt the shape. At the same time, care should be taken lest the cover be thus given a fantastic shape, which could give it away, particularly if it is out in the open.

The cloth cover is not likely to provide a perfect match with the ground, but it may be close enough to fool all but the most intent observers. Even so, what gives the camouflage away may be the sudden transition between cloth and ground. This transition can be masked by scattering soil or foliage -- depending on the situation -- on the outermost parts of the cover.

Where possible, the slope of a cover should be kept at less than 15° with the horizontal. Thus the cover will cast no shadow when the sun is high and brightest. Even at 15° elevation the sun may at times cast a strong shadow, but a 15° slope seems to be a good compromise with the much more impracticable slope of 5°, at which elevation, approximately, the brightness of the sun equals that of the sky, and there are no shadows out in the open.

4.4. Screens can be made out of anything that will satisfy the requirements of a camouflage task. Nets can be used, or burlap -- or even paper -- stretched on wood or wire frames. Their most obvious use is to provide "ordinary" camouflage -- camouflage in which some object is concealed and also the fact that it is being concealed. But as

mentioned in Section 4.7, screens can be used, boldly and obviously, to deny the enemy the advantage of precise information. Weapons emplaced behind or under screens will take longer to pin-point, and under their cover men can move back and forth easily in the knowledge that they are harder for the enemy to pick off. Screens can also be used to mask road turn-offs or new roads cut for the installation. The open sides of flat-top nets can be concealed by screens.

Disruption of outline can be achieved through the use of screens of irregular shape. They can be laid over roofs and projected over edges, or they can be set up vertical -- butress-like -- against walls. Screens can be so used as to provide shelter as well as camouflage.

4.5. Camouflage-Color Standards. There are two kinds of standards that are used in camouflage work: color chips and chromaticity polygons.

Color chips are useful in the field, or where quick judgements are necessary. One set can be found in Army Field Manual FM 5-22 (Camouflage Materials). Because color chips tend to fade with time and use, two sets of chips should be kept on hand: a working set and a set to be kept in a safe, dark place for an occasional check on the former. Air Force-Navy Bulletin No. 157e (Camouflage Colors, 1964) specifies camouflage colors by their numbers in Federal Standard No. 595 (Colors), as amended in 1960 by Addendum No. 2.

2. Chromaticity diagrams are used in some of the more recent Department of Defense specifications. The reader will find a recent revision in Amendment 4 (1966) to specifications MIL-C-765B (Cloth, Camouflage: Impregnated, Flame-Resistant; Osnaburg and Burlap; 100-Yard Rolls). And any complete reference work on illumination or color should have a description of chromaticity coordinates. The advantage in the use of chromaticity diagrams is that the uncertainty of subjective tests is obviated, in that the colors are specified by objective tests requiring calibrated instruments, so that the latitude admitted to manufacturers in fulfilling contracts is precisely delineated.

Some of the colors of Federal Standard No. 595 (Colors) are identified by chromaticity coordinates in Military

Standard MIL-STD-795 (Colors, a collection of spectral reflectance curves and chromaticity values for many of the colors in Federal Standard No. 595). We have identified only seven camouflage **chip-colors** as positively lying within the camouflage - color chromaticity polygons. These are #30277 (Sand) -- (3) Sand; #30228 (Field Drab or Dark Earth) -- (4) Field drab; #30099 (Earth Brown) -- (5) Earth brown; #30117 (Earth Red) -- (8) Earth red; #17886 (glossy white) -- (11) White; #34079 (Forest Green or Shadow Green) -- (12) Forest green; #30324 -- (13) Desert sand.

# CHAPTER 5

## CAMOUFLAGE PAINTS AND COATINGS

5.1. Introduction. Army Field Manual FM 5-20, Camouflage, Basic Principles and Field Camouflage (1959), provides (in Sections 111 to 115) a brief and useful introduction to camouflage painting. Its usefulness lies in part in its dispelling misconceptions the novice may have formed from popular accounts of camouflage painting in recent wars. It treats only aircraft camouflage, but the same ideas are applicable also to buildings and shelters. The following points bear emphasing.

1. In this study the purpose of camouflage painting is to blend an object into its surroundings, distorting features, minimizing contrast with terrain coloration, and reducing shine.

2. Aircraft are camouflaged to escape detection only while parked. No consideration is given to camouflaging aircraft in flight.

3. There is a basic camouflage color for each kind of terrain. This color itself provides a high degree of concealment. It is applied in a uniform coat over the entire surface to be painted.

4. But in some situations camouflage may be improved with a disruptive scheme. Such a scheme is created by painting large irregular patches of the appropriate secondary color over the basic-color coat.

5. The purpose of the two-color disruptive scheme is to disrupt the outline of the object, not to produce color illusions.

6. A few disruptive schemes for aircraft are presented in Army Field Manual FM 5-20. They are intended to illustrate the principle of disruption. The schemes should be varied from one object to another.

7. Poorly chosen disruptive patterns tend to make the object more conspicuous instead of concealing it.

8. Camouflage painting is to be regarded as a valuable asset, but only when used in conjunction with normal camouflage precautions. Full advantage of camouflage painting can be had only if intelligent use is made of good siting, dispersion, camouflage discipline, natural foliage, and artificial materials.

5.2. Basic Camouflage Colors for Aircraft. For temperate, jungle, and partial snow areas, the basic camouflage color is Olive Drab. (A partial snow area is one where the terrain is not predominantly snow-covered or where there are snows of short duration.)

In arctic-type regions, where the terrain is predominantly snow-covered, the basic camouflage color is Insignia White.

For the desert areas, Sand, Desert Sand, Earth Yellow, Earth Red, or even a mixture of these can be used as a basic camouflage color. These color names are taken from FM 5-20, and there is some uncertainty as to which colors they correspond to in Federal Standard No. 595 (Colors). However, no single color can be specified for all desert terrain, so the reader can get a good idea of what is suitable even from the foregoing imprecise designations.

5.3. Secondary Camouflage Colors. For temperate and jungle areas and other areas of dense vegetation, lusterless Black is the secondary camouflage color.

In desert areas lusterless Black is appropriate as the secondary camouflage color, except where the shadows are very light, in which case Olive Drab should be used.

Disruptive schemes are not recommended for arctic-type and partial snow areas.

The foregoing are recommendations, not prescriptions. The camoufleur may be able to improve upon them. The simpler the camouflage scheme, the lighter the logistical burden of a mission. The value of a disruptive scheme in a given situation may be marginal, so other considerations may take precedence. This subject is treated in Reference 11 ., which recommends a more elaborate combination of basic and secondary camouflage colors.

5.4. Standards. The standard aircraft camouflage colors for Air Force and Navy aircraft are listed in Air Force-Navy Bulletin No. 157e, Colors; List of Standard Aircraft (1964).

The reader should be wary of the confusion that can arise from the existence of different color standards. The same name may refer to two or even three different colors. Specifications for paints and such are explicit as to the standards to be consulted. But while the Olive Drab of FM 5-20 (published in 1959) is probably number 34087 in Federal Standard No. 595 (1956), the Olive Drab listed in ANA Bulletin No. 157e (1964), is the interim color designated by X34087 in Addendum Number 2 (1960) to Federal Standard No. 595.

Fifteen of the colors listed in ANA Bulletin No. 157e may be of interest to land camoufleurs. Of these, eight are described by tristimulus values and photometric curves in MIL-STD-795, Military Standard:Colors (1962). These latter are Interior Green, Medium Green, Middlestone, Desert Sand (formerly Sand), Dark Earth, Dull Red, Desert Drab, and Shadow Green.

Ordinarily, targets are detected because of contrasts between them and their backgrounds. Camouflage blending is the process of eliminating or reducing these contrasts. The principal contrast is that of tone (value), the dark and light relationship between an object and its background. Hue (that quality according to which we identify a color as red, blue, etc.) is important when the range of observation is short or the object to be camouflaged is large. But tone should be the first consideration for the camoufleur in choosing camouflage materials. Lusterless colors are always used for land camouflage. Other things being equal, an object that is darker than its background is less noticeable than an object that is lighter than its background. Paint can be toned down by mixing soot or dark earth into it. Such toning down, however, should be attempted only under advisement, for the mixture may dry out to a rough coat, which can affect the performance of aircraft it is applied to. Moreover, such mixing can lessen the infra-red reflectance of some of the paints.

5.5. Countershading is painting the under-surfaces of objects lighter than their upper surfaces. It is held that one of the factors in detecting solid objects from above is the fact that the under-surfaces, as they receive less light than the upper surfaces, are in shadow. If the undersurfaces are lighter in color than the upper surfaces, the object is less noticeable as solid. For this reason, it is said that the light ventral surfaces observed of many animals make for greater survivability. Countershading, like other disruptive schemes, should be regarded as supplemental to the basic camouflage coat.

5.6. Camouflage of Structures. As already remarked, the principles inherent in the foregoing apply also to the camouflage of buildings and shelters and the like. Large structures, of course, pose special problems, and how these problems are handled depends upon the ingenuity of the camoufleur, his resources, and the attitude of the commander in the field.

The way large surfaces are coated depends upon the background and the coating preparations available. It is always to be understood that camouflage painting supplements other methods. A solid coat in the appropriate basic color is in most cases desirable. In some situations an object just cannot be hidden; valuable camouflage supplies should then be saved for other targets.

The situation dictates the kind of disruptive scheme used:

1. When a building is sited among trees or bushes, or where irregularities in the ground create a lot of shadow, the disruptive scheme can consist of large, irregular patches. But nets and natural foliage are more appropriate in such cases. In Reference 12 a procedure is described for laying out a disruptive scheme.

2. When a building is sited out in the open in a uniform background (as for instance in a large grassy clearing or in a field of snow), a disruptive scheme would call attention to itself and so should not be used.

3. When a building is sited out in the open where the surface is interrupted by such terrain features as roads, streams, hedgerows, and the boundaries of variously cultivated fields, the disruptive scheme should mimic such variation when observed from the air. It is difficult to specify which paint or other coating can be used to achieve such conformity. But even here,

matching of tones is the most important consideration. Whatever effect is intended, the scheme should be checked by careful scrutiny from the air.

4. When a large building is sited in an urban or otherwise densely settled area, the disruptive scheme should match the regularity of its surroundings. The usual trick is to work over the roof to make the single building look like a few small buildings from the air perhaps even with a simulated road or street running through. The reader is directed to References 12-14 for more information on this subject.

5.7. Blackout Painting. The outsides of glass windows can be painted the same color as the enclosing surface, so long as the paint is thick enough to keep light from escaping. But if the window is exposed to sunlight for long periods of time, the paint may absorb enough heat to crack the glass it is applied to. Windows so painted must be shielded against the sun or camouflaged a different way.

When blackout screens are used inside to cover windows, the inside window-frame and wall should be painted dull black to at least a few inches beyond where the screen touches.

5.8. Paved Surfaces. In the days before jet fighters and bombers, it was the recommended practice to use bituminous emulsions for toning down paved surfaces like runways, taxiways, hardstands, and roads. (A bituminous emulsion is a mixture of asphalt or other bitumen in a liquid; it can be pigmented.) But such preparations, as well as other coatings which leave a soft film on the surface, should be avoided, since they may flame or soften under jet motor blasts, causing fire and skid hazards to other aircraft. Army Field Manual FM 5-22, Camouflage Materials (1956; Change No. 1, 1959), recommends the stains described in its own Tables XII andXLI. But Table XLI is rescinded by Change No. 1. The Change also contains the lengthy Table XII, but it is not certain whether this is the same table as appears in the basic manual. Lacking assurance in this matter, the reader should of course consult the table in the Change.

5.9. Ground Observation. The reader will note that the methods described in the foregoing are directed toward thwarting observation from the air. Obviously, they apply also for ground observation at a distance. Even though at short range hue is more important, relative to

tone, a good "long-range" camouflage job will certainly afford some protection against short-range observation. And the work will be more effective, the more care is given to matching hue as well as tone.

# CHAPTER 6

## DECOYS

6.1. Introduction. With the development of long-range weaponry (including the airplane) the design and development of decoys has become almost an art. This assertion is supported by the variety of detail in Army Field Manual FM 5-23, Field Decoy Installations.

Decoys can be used for a number of purposes. The six most common are (1) to lead the enemy to believe you have taken a particular course of action; (2) to absorb some of the attack, thereby limiting losses; (3) to lead the enemy to believe your forces are where they are not; (4) to introduce one more element of uncertainty into his deliberations; (5) to deceive the enemy as to the size or nature of your force, and (6) to confuse attackers.

These purposes are served by a variety of measures. The use of dummy shelters and equipment is the most familiar. The decoyist has other, less obvious devices, such as decoy tracks, smoke, and even simulated damage. Some of these will be described below. For a more thorough treatment of these matters the reader is referred to FM 5-23.

A poorly planned or conceived decoy installation can very well give the enemy information he might not otherwise obtain. For instance, when such an installation is clearly recognized for what it is, the enemy's task of locating the real installation is made that much easier. Short of such consequences, decoys at the very least will complicate the enemy's deliberations.

6.2. Detail. A decoy installation must offer the enemy enough clues to make a convincing "picture" for him. Dummy aircraft, tanks, motor vehicles, artillery, and buildings can be built in the field. Pre-fabricated pneumatic versions of some of these are available through supply channels. There are methods described in FM 5-23 for simulating trenches, lights, fires, shell holes, and damaged structures, but the amount of detail employed need be no more than that required to produce the effect intended.

The kind of detail employed in a given situation depends upon the kind of observation the decoy is subjected to. Photo interpreters draw their conclusions from an analysis of the activity in an area rather than from the details or separate objects. On the other hand, the appeal of a decoy or decoy installation must be less subtle when directed toward the combat pilot.

6.3. Development in Time. Large installations do not spring up overnight. When the enemy detects signs of possible activity, he examines (if he can) photographs of the same area taken earlier. If they do not show activity in that place a reasonably short time before, he will suspect the fraud. Ordinarily, decoy installations should be built at the same rate as would be the installation to be simulated.

A classic ruse was Montgomery's employment of decoys in the defense of El Alamein. The build-up of the dummy supply dumps was so scheduled as to lead Rommel to anticipate Montgomery's counter-attack is the wrong place and at the wrong time. Rommel was kept guessing and finally detected the deception, three days before Montgomery's break-out, but too late to recall his detached 21st Panzer Division.

6.4. Camouflage is a normal part of every military operation. Decoys must therefore be camouflaged with enough care so as not to arouse suspicion. The enemy must be permitted to "see through" the camouflage without seeing the deception. The flaw in the camouflage must be such as will attract attention but at the same time must not be an obvious give-away. Breaches in camouflage discipline which are typical of careless troops are best for this purpose.

6.5. Signs of Activity. The camoufleur should know how reconnaissance is carried out and how photographic records are studied. It is to the decoyist that this knowledge is most vital. The photo interpreter can detect, by certain signs, not only the fact that an area is being used by a military force, but also the nature and size of that force. The decoyist therefore must make sure that the "signs" he leaves characterize military activity, both in general characteristics and as regards the kind of installation simulated.

Certain features are common to military installations: tracks, spoil, shelters, latrines, buried cable, barbed wire, and mine fields.

Air bases must feature runways, taxiways, and hardstands, as well as anti-aircraft artillery, access roads, service roads, gasoline-storage, bomb dumps, and sometimes a control tower and other buildings.

A marking on the ground identifiable in an aerial photograph as peculiar to a certain object is known as that object's signature.

6.6. Tracks. Tracks are an important and obvious part of the signature of construction or field activity.

Foot tracks should be made by actual foot traffic. Straw or hay may be scattered to give the effect of frequent use. If the site is to appear continuously occupied, the tracks must be constantly increased in intensity and width.

Wheel tracks are best made by running several vehicles through the area to create the image desired. Dragging chains or logs through the area creates a more conspicuous scarring of the ground.

Caterpillar tracks can be made only by a tracked vehicle. These tracks do not need to be renewed as often as foot tracks and wheel tracks.

6.7. Other Features Common to Military Installations. Spoil is usually conspicuous near all dug positions. The practice of regular units in the neighborhood will determine whether spoil is required at decoy positions. The best way to produce the appearance of spoil is to spread the earth from a real excavation, though the excavation need not be as deep nor the spoil piled as high as in the genuine position. The trampling of the ground by working parties flattens vegetation and compacts the ground. This effect is minimal on rock or sand surfaces but on unvegetated clay the compacting will cause a lighter tone in both the visible and near infrared. In vegetated areas, the trampling will lighten the tone in the visible range but darken it in the infrared.

Latrines are a feature of every occupied site. They are usually disclosed by converging tracks that become more marked as time passes.

Buried cable is frequently an adjunct of important headquarters but may also be associated with radar installations. It appears like a track, light in tone, and decreases slightly in visibility with time. It is usually straight with angular turns.

Barbed wire itself is not visible in aerial photographs, but its presence may be revealed by the tracks and trampling of the wiring party. After several days, the location of the wire is disclosed by a faint gray line under the wire which gets darker and more pronounced as time passes, because of the accumulation of untrampled vegetation underneath. Gaps in the wire often give away its presence, because of tracks which converge and diverge with no apparent relation to the topography.

Minefields, like wire, are detected in aerial photographs by the otherwise unexplainable convergence of tracks. Single mines are unnoticeable. A barely visible decoy field of refilled holes may be noticed if they form some kind of pattern.

6.8. Decoy Airfields. Two kinds of decoy airfield were employed in World War II: day decoy fields and night decoy fields. The day decoy fields consisted of dummy runways, buildings, access roads, storage huts, and so on. The night decoy fields consisted mostly of lights, and were not intended to be visible during the day. Normally the day and night decoy fields were separate installations. The decoy field was employed to protect a real airfield in the neighborhood by absorbing attacks intended for the latter. Sub-Sections 1 through 4 below apply to both kinds of field, while 5 through 6 apply only to day fields. Complete decoy airfields are not presently considered useful.

6.8.1. Offset Distance. The distance between the decoy airfield and its real counterpart was from 4 to 8 miles. A decoy situated more than 8 miles from the real airfield was likely to be regarded as an entirely separate airfield and cause the enemy to search further for the camouflaged real field.

6.8.2. Operational Prerequisites. Suitable terrain with adequate drainage was deemed important for the site of the decoy airfield.

6.8.3. Positioning the Decoy in Relation to Landmarks. As far as was possible, the decoy airfield was to be so situated that its relation to important landmarks and terrain features (lakes, rivers, railroads, highways, wooded areas, cultivated fields, etc.) was similar to that of the real airfield. In some cases it may have been practical to simulate some of these landmarks, as dummies, while the decoy airfield was under construction.

6.8.4. Relation of the Decoy to the Probable Route of Enemy Approach. A decoy airfield was generally to be located in the path of the most likely approach an enemy would follow to the real field. He would then see the decoy first. It may have been necessary, however, to forgo this consideration if the terrain, or prominent landmarks, suggested a much more desirable site in some other direction from the real field than that of probable enemy approach.

6.8.5. Size of Decoy Airfields. A day decoy field was to be about the same size as the real field, or the standard size of similar known operational fields, as the enemy aerial photograph interpreters could scale its actual size for comparison with their knowledge of the real field or of other airfields of ours.

6.8.6. Aircraft Activity. The complete absence of air traffic could give a decoy field away, if the enemy had it under surveillance. Signs of air activity could be given through the use of light planes operating off a rough strip. The decoy field could even be an operational field of less importance than the one protected.

6.9. Construction of Decoy Airfields. Army Field Manual FM 5-23 prescribes the following order in the construction of the various features of a decoy airfield: (1) runways, taxiways, and hardstands; (2) access roads and service roads; (3) bomb and gas-storage dumps; (4) control tower and buildings (when appropriate); (5) camouflage. The manual offers greater detail, as well as construction estimates as of 1956. Improvements in reconnaissance necessitate greater fidelity in decoys, and so the expense in time, labor, material, and money may be much greater than what it was then.

6.10. Defects. Representative defects of decoy installations include (1) regularity of tracks, (2) absence of litter associated with occupation, (3) flatness (absence of stereoscopic relief), (4) failure to simulate any particular type of installation, (5) absence of movement and motor transportation, (6) unchanging appearance, (7) incorrect tacticalpositioning, (8) an unrealistic rate of buildup or removal, (9) absence of real anti-aircraft defense, and (10) failure to simulate a necessary component of a particular installation.

6.11. Night Decoys. Night decoys were used extensively in World War II. They were most valuable in misleading enemy bomber attacks at night. Captured operational maps showed night decoy installations, particularly of airfields, marked down as real targets.

Night decoys employed lights, fires, smoke, and pyrotechnics. A decoy could be one small simulated street light, or it could be a complicated installation composed of hundreds of firemaking and lighting devices which when ignited simulated a burning supply depot, factory, airfield, town, or city.

The effectiveness of a night decoy installation depended upon (1) verisimilitude, (2) the adequacy of the camouflage of the real installation, and (3) the vigor of the defense.

It should be borne in mind thatthe realism of a decoy depends upon the proficiency of enemy reconnaissance and attack. As in all kinds of camouflage work, the decoyist must consider how the installation appears to others, not how it conforms to his preconceptions.

Since night decoys used light to attract the enemy, they could be successful only when the surrounding territory was blacked out. All measures which made the real target more difficult to locate increased the effectiveness of the deception. Fires started by bombing of the real installation were to be extinguished immediately. If they could not be put out, further deception operations were not worthwhile against successive waves of attackers unless a comparable fire, or one more convincing, was started at the decoy site to entice follow-up attackers away from the real installation.

The enemy attacking should not be given time to think.

A prompt, vigorous defense will force him to judge more instinctively and less rationally. Aviators, especially, are attracted by lights and are often eager to accept any plausible semblance of a target as the real one.

6.12. Primary and Secondary Lighting. There are two classes of lighting for night decoy installations: primary and secondary.

Primary lights simulated lighting in blackout areas which was normally turned off upon receipt of the alert signal. Examples: factory exterior lights, lighted windows, signal lights, dock or freight yard lights, and the flash from an electric welder.

Secondary, or residual, lighting represented lighting which could not be extinguished immediately upon receipt of a warning, such as the glow from a furnace or coke oven and lights due to poor blackout discipline.

6.13. Pre-Fabricated Pneumatic Decoy Targets. As of the present, there are no specifications in force for pre-fabricated decoy aircraft. There had been specifications for a partly pneumatic pre-fabricated dummy F-86F jet fighter-bomber, but these were cancelled on May 16, 1966. The F-86F dummies are no longer in use, since the F-86F went out of production in 1956 in this country and in 1961 in Japan. The F-86F is still in use in Japan, Pakistan, and Thailand, but the decoys are not known to be employed in those countries.

Specifications are available for pre-fabricated pneumatic dummy versions of ten common pieces of ground equipment (listed in the next section). The general construction of these dummies is covered in Military Specification MIL-D-52048 (CE), as amended, Decoy Targets, Low Fidelity, Pneumatic, General Construction Material for, and Packaging of. Each decoy consists of a framework of one or more pneumatic tube systems over which is attached a fabric cover. This cover is aluminized in places, but otherwise the fabric is to match color No. 34087 (Olive Drab) of Federal Standard No. 595 and is to have an infrared relectance between 5.0 and 12.0% in each of the ranges 697.5 - 854.2 mμ and 926 - 1099 mμ.

6.14. Pre-Fabricated Pneumatic Decoy Targets in the DoD Specifications Series MIL-D-52048/ (CE). The following

is a list of currently available pneumatic decoys. The shipping volumes are the ones given in the specifications, to which the reader is referred for further information.

1. Howitzer: Medium, Towed, 155-mm. Shipping volume, 30 cu ft.
2. Gun: Field Artillery, Towed, 155-mm. Shipping volume 30 cu. ft.
3. Howitzer: Light, Towed, 105-mm. Shipping volume, 16, cu. ft.
4. Tank: Combat, Full Tracked, Medium, 76-mm Gun, M 41. Shipping volume, 81 cu. ft.
5. Tractor: Full-Tracked, High-Speed, M8A1. Shipping volume, 81 cu. ft.
6. Tractor: Full Tracked, High-Speed, M5. Shipping volume 55 cu. ft.
7. Truck: Cargo, 2 1/2-Ton, 6x6, M34. Shipping volume, 55 cu. ft.
8. Truck: Wrecker; Medium, 5-Ton, 6x6, M62, W/Winch, W/E. Shipping volume, 55 cu. ft.
9. Gun, Anti-aircraft: Self-propelled, 40 mm. Shipping volume, 55 cu. ft.
10. Howitzer: Self-Propelled 105-mm. Shipping volume, 81 cu. ft.

6.15. Other Pre-Fabricated Decoys. Decoy Target, Bailey Bridge, Double Double. MIL-D-52165 (CE). 1961 -- A Bailey bridge is a bridge designed for rapid construction from interchangeable latticed panels of electrically welded high-tensile steel which are coupled into girders with alloy steel pins and laid double or triple or superposed to suit the span and load. The most conspicuous features of such a bridge, the steel roadway and footwalk, are simulated by cotton duck cloth and cotton webbing, both dyed Dark Gull Gray (#36231 in Federal Standard No. 595) and with infrared reflectances between 15 and 24 percent.

Decoy Target, F-86F Aircraft, Type MC-2. MIL-D-26049A. CANCELLED May 16, 1966 -- This decoy was intended to be used to simulate a parked F-86F airplane for visual, photographic, and radar observation at a minimum distance of 1500 feet. Details featured included a tail-pipe, external fuel tanks, pylon and tires. The wings were of foam resin core material. The fuselage was a tubular steel frame covered with nylon cloth and was to hold compressed air. The decoy came in parts and was so

designed that it could be "assembled and disassembled" in not more than 60 minutes by a four man crew. The unassembled, packaged unit was to be of such size that it could be shipped in a C-47 aircraft. There have been two designs for the F-86 decoy tested. When crated for shipment, the first had a weight of 2909 pounds and a volume of 296 $ft^3$. The second had a weight of 1363 pounds and a volume of 340 $ft^3$. (Reference 15)

6.16. Construction of Decoys in the Field. Wood, wire and burlap were the most useful materials for constructing dummies in World War II. These materials may be available through supply channels, but salvaged equipment and materials of local manufacture may also be suitable. Decoys can be made of salvaged tenting, creates and boxes (stacked to resemble what is to be simulated), and parts of wrecked equipment. Equipment or positions can also be simulated by digging shallow outlines in the ground or by painting either on cloth or on the ground. This method is effective only as a temporary measure, since the absence of height and perspective will be apparent in stereoscopic and low-oblique photographs.

6.17. Construction Time Estimates. A chart is presented in Army Field Manual FM 5-23 of the estimated number of man-hours required for the construction of three-dimensional dummies of various types of equipment. The actual time required on any project will, of course, depend upon the design of the decoy and the material used.

6.18. Aircraft Decoys. Two classes of field-expedient aircraft decoys are described in Army Field Manual FM 5-23. These were developed before 1938. The newer, pre-fabricated pneumatic and vacuum-formed decoys (such as the one described in Section 6.15) are of course better but have defects in terms of realism.

Wings, fuselages, and tail parts of damaged or wrecked planes can be placed projecting from under a tree, bush, clump, or camouflage net to suggest real aircraft partially camouflaged. Parts should be put high enough to cast a realistic shadow. This is one of the simplest and most effective ways of simulating aircraft and other objects.

6.19. Buildings and Other Shelters can be simulated by painting a full-size aerial view of the structure on a large piece of burlap or some other suitable material.

A three-dimensional building-decoy need not be a complete replica if the decoyist is concerned only with observation from above. It can be little more than a lumber-frame roof

covered with garnished chicken wire and supported 4 or 5 feet above the ground so that a real shadow is cast. Painted canvas or Osnaburg is laid horizontal and is nailed to the frame around the base of the roof supports to give the appearance of sides when seen from the air.

Simulated warehouse buildings are useful in drawing enemy attacks from high-priority targets to lower-priority targets. They are particularly useful in barren country, where military activity of all kinds is difficult or impossible to conceal. The decoy warehouses can be made of lumber frameworks covered with painted burlap or Osnaburg.

Plans and bills of materials for constructing simulated buildings, shelter tents, kitchen flies, and pyramidal tents are given in Army Field Manual FM 5-23.

6.20. Other Decoys That Can Be Built in the Field. Other passive decoys that can be built in the field include guns, piers, barges, mooring buoys, railroad tracks and rolling stock, land vehicles, fuel containers, trees, bushes, rocks, and people. Construction of these devices is detailed in articles 67 to 70 of FM 5-23. Article 66 of that manual suggests ways of simulating damage. And Chapter 7 therein describes flash simulators.

6.21. Simulators. Specifications are available for devices called simulators, most of which are designed for use in field exercises but could prove useful at an air base. Their construction can be only guessed at from the specifications, as this information is provided only in drawings and perhaps in the manuals of instruction that must be issued with the equipment.

## CHAPTER 7

## FIELDWORKS

7.1. Introduction. The buildings, hangars, and other shelters ordinarily found on air bases can be detected and recognized by their shapes. The larger buildings especially can be conspicuous. The ground plans of practically all buildings are either rectangular or made up of rectangles. Techniques may be developed in the future whereby buildings can be constructed with irregular shapes, if such indeed will be acceptable from other points of view than that of camouflage. Until such time, disruption of outline will remain one of the principal measures for camouflaging buildings. The same can be said for most large tents. Inflatable structures for example, can be designed in irregular shapes, within limitations, and may find acceptance for most uses, as warehouses and quarters.

The means employed in camouflaging buildings are described elsewhere in this handbook.

Some fieldworks have camouflage incorporated in their construction. This chapter deals with such camouflage. For more detailed information on fieldworks the reader is referred to Army Field Manual FM 5-15, Field Fortifications.

7.2. Underground Shelters. An underground shelter can be completely submerged or partially submerged. The partially submerged shelter has all the normal camouflage advantages that low structures have over high structures -- like less vertical area exposed to observation and fire, a smaller shadow, and less effort required in covering. The completely submerged shelter (one whose roof is level with ground) enjoys these advantages to their fullest extent. But it may not be practical to make completely submerged shelters in a given place: the water table may be too high, or the bedrock may be near the surface.

A partially submerged shelter can be just a conventional building with a submerged floor, it can be made completely out of materials found in the field, or it can be something in-between.

Submerged structures are of especial importance these days because of the protection from nuclear radiation afforded

by thick layers of earth. The earth usually has to be dug up so that it can be packed around and over the structure. Disturbed earth can be markedly different in tone from undisturbed earth. It will be necessary to reduce this contrast if the structure is in an exposed position. (1) The earth-mound can be packed with sod taken from an area where its removal will not be noticed. (2) The mound can be strewn with cut vegetation, and even live bushes or trees can be transplanted onto it. (3) If the turned-up earth is lighter than the undisturbed soil, it can be toned down with waste oil, sawdust, wood chips, and even with water (the last as a temporary measure).

The packing of earth about a shelter can be done in a way to contribute to its camouflage. The earth can be sloped gently to the ground, to reduce shadow, or it can be packed into an irregular shape, for disruption of outline.

7.3. "Revetments." As pointed out elsewhere, a revetment is a facing for an earth wall, but the word is used loosely to designate an incomplete enclosure, not necessarily roofed, with a wide, open mouth, used to protect its interior from observation, blast, and flat-trajectory fire. The wall can be made of anything suitable, but some materials (like earth) lend themselves more readily to camouflage. Camouflage nets can be spread from wall to wall to secure the interior from aerial observation, and across the mouth, against observation from the side.

Such "revetments" have often found use as shelter for combat aircraft. The Japanese used them (roofed) in some areas in World War II to conceal the number and nature of their aircraft.

7.4. Apertures. The deepest shade observable from without is that of apertures -- entrances, windows, firing ports. It is particularly revealing in aerial photographs but not likely to attract attention otherwise.

Apertures may be shuttered when not in use. Any covering, such as an empty sandbag on a light wooden frame, will be satisfactory for concealment. It will help to erect an apron over the aperture. Camouflage nets hung as screens can be used for the entrances of the "revetments" of Section 7.3.

If light-proof blast-baffle walls or gas-proof air locks

are not built into a shelter, blackout curtains should be hung in all entrances. They should be hung in pairs, so that one may shield the other when a person passes through. Issue blankets can be used as light-curtains.

7.5. Heating and Cooking. The smoke from fires during the day, and at night their light, can give a position away.

Most fuels can be burned without a stove, but it is never safe to have an open fire in a closed shelter. Gases resulting from incomplete combustion may be very toxic. All heating in shelters should be by some kind of stove which is vented to remove the combustion products from the shelter. A plentiful supply of air to the burning fuel insures its efficient use and curtails the production of dark smoke and noxious gases.

Army Field Manual FM 5-15 (Field Fortifications) provides diagrams of stoves that can be made in the field for burning coal, coke, wood, charcoal, and diesel fuel. Charcoal is an excellent fuel because it gives off very little smoke or light and will burn for a long time. It is also light-weight, easily transported, and a safe to handle and use. Coal is also safe and easy to handle, but it is heavy, difficult to ignite, and gives off light and smoke. Coke has some of the advantages of charcoal, in that it is light-weight and burns long with little smoke or light, but it is more difficult to ignite. Diesel fuel is usually available and is easily transported, but it is dangerous to burn as fuel in shelters or emplacements and it gives off smoke and light. (An emplacement is a prepared position for the protection and operation of weapons or other equipment.) Gasoline is usually available and easy to transport. It can be burned with little or no smoke. It is very dangerous to use in either a shelter or an emplacement and gives off light. Wood is usually the most plentiful fuel. It is easy to handle and transport, is relatively safe, and gives off a lot of heat as long as it lasts. But it cannot be burned without giving off some smoke and light, and large quantities are required, as compared to other fuels.

Damp wood and wood recently cut smoke heavily when burned. Dry wood picked up off the ground does not smoke heavily and is therefore preferable as fuel. You can hasten the drying of wood by splitting it so as to expose more surface to the air.

In cold weather the water vapor in smoke is condensed to form a white mist which may be slow to disperse. This mist may give a position away.

More heat can be got out of a stove setup by extending the stovepipe under the floor of the shelter. Moreover, the greater length of pipe and the attendant cooling of the smoke will cause some precipitation of solid matter and some condensation of vapor, this somewhat thinning out the smoke finally expelled into the air.

7.6. Camouflage Cover for Small Emplacements. One satisfactory camouflage cover for foxholes and small emplacements consists of a light, open grid of branches garnished with grass or other plants. Another is a shelter-half, or anything else appropriate, covered with a suitable material, like snow or earth, according to conditions. The cover is so made that the occupant can raise one side for observation or firing.

7.7. Obstacles. The use and construction of obstacles is described in Army Field Manual FM 5-15 (Field Fortifications). Whether or not they are camouflaged depends upon their purpose.

If their purpose is to induce the enemy to use other approaches than the ones guarded, then obviously they should not be camouflaged. Dummy obstacles can be used for this purpose, and the camoufleur's technical skill may come in handy in the construction of dummy pillboxes, tank traps, guard posts, observation posts, and such.

When obstacles are used to delay the movements of the enemy, their effectiveness is enhanced by camouflage. For if the enemy is not prepared for an obstacle, he must reduce it without benefit of prior planning. If the obstacle is defended, the defender has the advantage of the enemy's first reaction, which is usually confusion. Obstacles are usually camouflaged by hiding them, by placement (as in natural depressions, around curves in roads, and just over the tops of hills) or by simple screening.

# CHAPTER 8

8.1. Introduction. Smoke screens have four principal uses: (1) to deny targets to enemy fire or objectives to his attack, (2) to "blind" the enemy by reducing the visibility of his own surroundings, (3) to mark targets or objectives, and (4) to provide some protection against a nuclear explosion. We will take up only the first two of these uses, the latter two having nothing to do with camouflage.

The first category of uses find its greatest potential in planned attack. Here some screens can be used, in concealing advancing forces, (a) to conceal the nature of those forces and (b) to make the defenders waste ammunition; in covering a wide front, (c) to deny him information as to the path of an impending attack, as a deception (d) to divert his attention; in causing false alarms, (e) to force his hand, discover weaknesses in his dispositions, disconcert his command, or demoralize his troops, and (f) to cover retreat or withdrawal or the recovery of the fallen. Smoke screens find less use in the defense of installations in the field. This is so because smoke screens usually take time to evolve, and the enemy is not likely to waive the advantage of surprise. But there are some tactical situations wherein an obscuring smoke screen will help the defense -- as for instance to protect buildings or equipment to which an enemy attacking on the ground must advance some distance under fire; to cover counter-attacks or withdrawals, and to divert the attacker's attention or fire. The use of smoke in decoys is covered in Chapter 6 (Decoys). The enemy can be "blinded" by a smoke screen laid around him. One smoke-grenade may be enough to render ineffective the fire from an impregnable position. Men well concealed in a dense wood will, for all practical purposes, be made no less invisible by a smoke screen laid around them, but they may thereby be deprived of the ability to observe the ground and their objective, while for the defenders the field is yet clear all around. This incapacitating smoke screen may serve another end, the disclosure of insurgents among a civilian population, if the smoke includes a mild eye irritant or some distinctive, un-washable skin dye.

There is some risk in using smoke screens, the risk inherent in the use of any agent that is difficult to control. Smoke screens are susceptible to changes in the wind and

air currents. A fall in wind speed can delay the evolution of the smoke screen at a crucial moment. A freshening of the wind can blow the smoke screen beyond its objective faster than the smoke-generating equipment can supply smoke, or it can disperse the smoke, exposing the positions or activities the smoke screen was to hide. A shift in the direction of the wind, by blowing smoke in a direction other than that intended, can also defeat the ends of a smoke screen. The risk lies not only in the exposure of positions and the frustration of plans but also in the possibility that the smoke will be driven, by either kind of change, into areas where its presence will hinder our operations or abet the enemy's.

8.2. The Nature of Smoke Smoke is an aerosol. An aerosol is a suspension of particulate matter in a gas -- air in the case of smoke. The suspended matter can be solid or liquid. If solid, the aerosol is called a smoke; if liquid, a mist. But it is convenient to use the word "smoke" to cover both kinds of aerosol. Where it is necessary to avoid ambiguity, the term "solid smoke" will be used. Some idea of the scale of numbers involved in the study of smoke will be given in the following paragraphs.

A convenient unit for the description of smoke particles is the micron (μ), which is one millionth of a meter.

Wood smoke is a solid smoke. The average particle diameter is 0.2 to 0.4μ, which is in the range of wavelength of ultraviolet radiation and also about a thousand times the molecule diameters. (The wavelengths of visible light fall roughly in the range 0.4μ [violet] to 0.7μ [red].) Particles of tobacco smoke are also of this size.

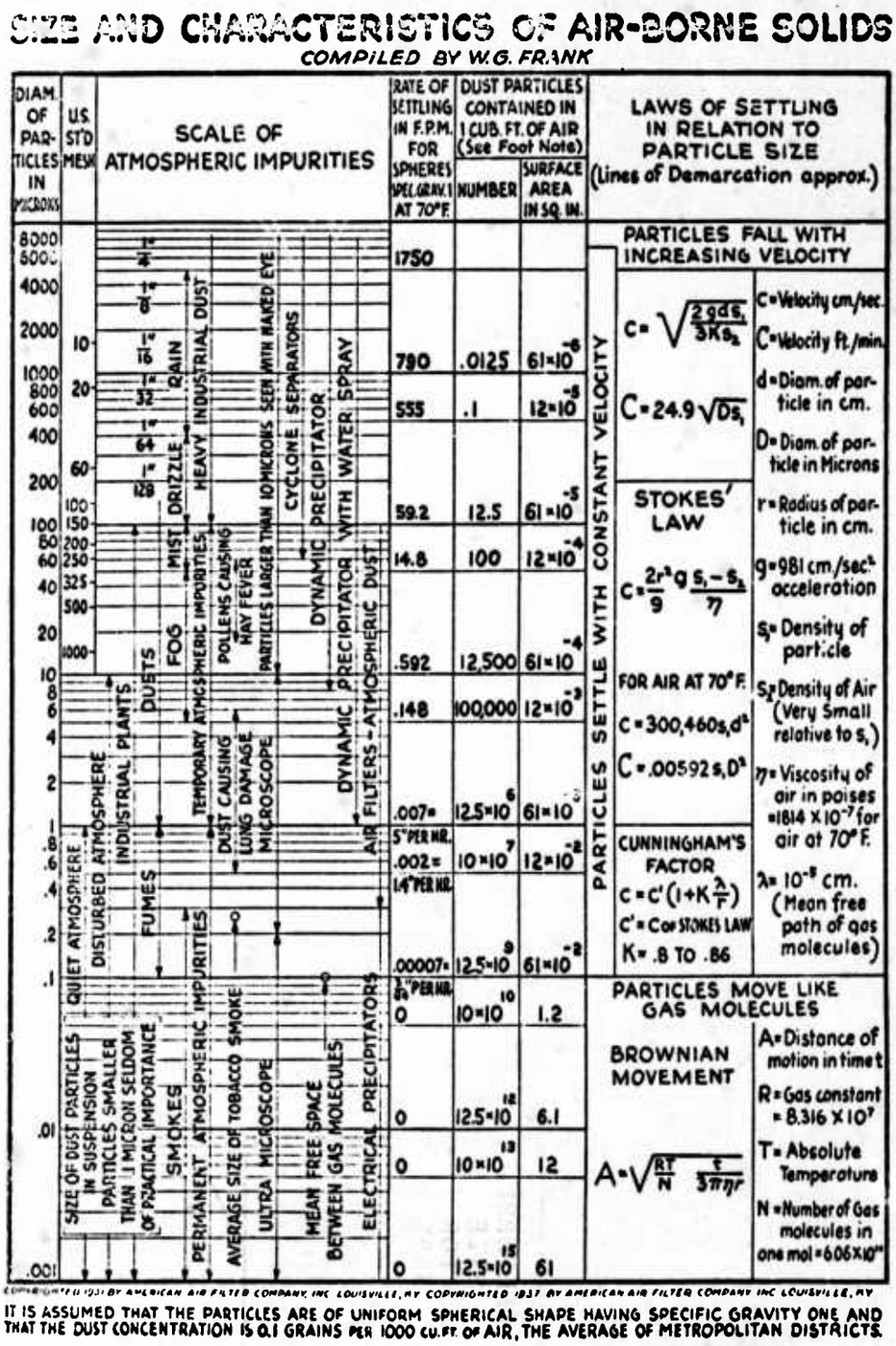
Mist particles are nearly spherical. Fog is a mist of water particles. Fog particles range in diameter from 4 to 50μ, which is in the range of wavelengths of the middle and far infrared.

The density of a liquid particle is the same as that of the bulk liquid. However, solid particles come in all shapes, and many are smaller particles stuck together (flocculated) with air spaces in between, so that little can be said about "particle density."

Fog and wood smoke were offered as examples of aerosols because everybody has seen these. Figure 1 presents, among other things, the ranges in size of a number of common aerosols, but not including those used in military operations. An East German book on this subject gives 0.1 to 10μas the range of diameters of mist particles and 0.001 to 0.1μ as the range for solid smoke particles. These figures probably pertain to military smokes alone, although the authors do not so assert. Referring to the Frank Chart (Figure 1), we see that the solid smoke particles fall in the region in which "particles move like gas molecules." That is, although they are at least ten times larger in diameter than the air molecules, collisions with the latter are enough to keep them from settling out. The Frank Chart shows that as the particle diameter increases above 0.1μ, the speed of settling increases, according to the formulas presented therein. Particles smaller than 1μ can cause lung damage (see Figure 2) and could be dangerous for the people using the smoke.

The rate of settling is one consideration to be entertained in developing smokes for camouflage. But the dominant factor in the evolution of a smoke screen is the wind and air currents. Even if the smoke is propelled at high speed from its source (as from a grenade), it is slowed down greatly by the resistance of the air. Thus, a 1-micron particle of initial speed 1000 ft/sec, according to Reference 16, will not travel 100 feet in 0.1 second, but only about ten inches.

# The Frank Chart




AMERICAN AIR FILTER CO., INC., DUST CONTROL PRODUCTS, LOUISVILLE, KY.

Figure 1. The Frank Chart

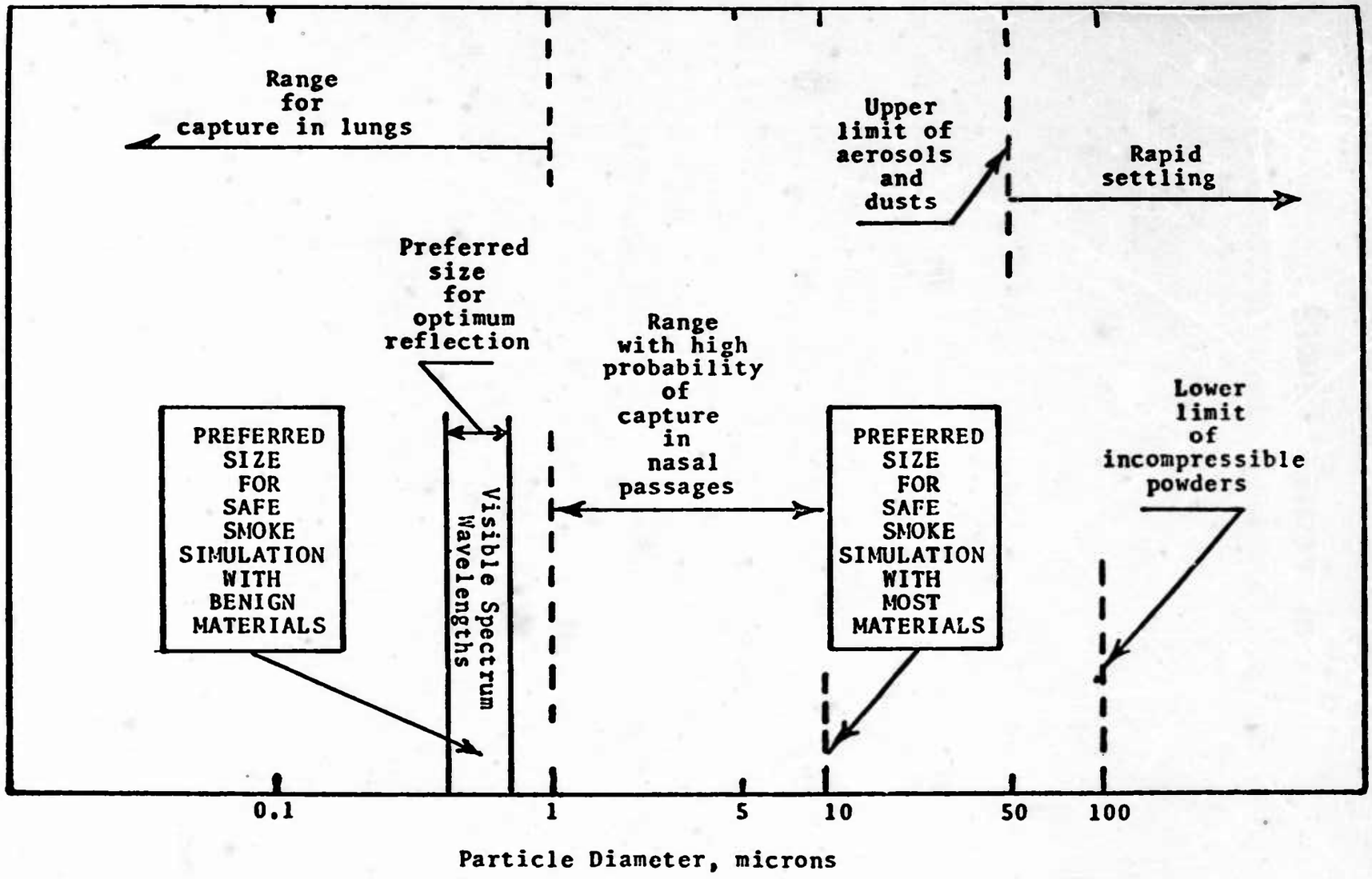



FIGURE 2. PREFERRED SIZES OF PARTICLES FOR SAFT SMOKE SIMULATION

8.3. Interaction of Smoke Particles. Another process that affects the behavior of aerosols is the increase in the average size of the particles through coagulation or through evaporation of the smaller particles. (Coagulation of solid particles is called flocculation.)

The kinetics of molecular gases has been the subject of the researches of some of the most brilliant theoretical physicists of the last hundred years. Because smoke and clouds constitute a special kind of gas, some of the ideas and results of kinetic theory can be utilized in their study.

Gene Wampfler (Reference 17) presents some results pertaining to these matters published by R.C. Tolman in 1919 (Reference 18) and some discussion of a book (Reference 19) by Whytlaw-Gray and Patterson published in 1932.

Treating the disappearance of smoke in a confined space, Tolman concluded that (a) the rate of disappearance is markedly increased by stirring and agitation, (b) the higher the concentration of smoke, the greater its rate of disappearance, (c) the rate of disappearance is greater for small particles than for large ones, and (d) it is impossible to raise the optical density of a smoke beyond a certain point by the introduction of more smoke, because increased concentration and increased subdivision both lead to a greater rate of disappearance.

Whytlaw-Gray and Patterson observed that the disappearance of smoke falls into three periods: (a) an unstable initial period in which the decrease in the number of particles is very rapid, (b) a stable period reached after some hours in which the change in number of particles is very slow and which may last up to 24 hours or longer, and (c) an intermediate period in which the rate of disappearance is the resultant of factors operative in (a) and (b). In the unstable initial period the rapid decrease in number is due almost entirely to coagulation.

Coagulation is inhibited when the particles have like electrostatic charges, and also if the particles are coated with an anti-coagulant.

Some writers assert that, when there is no electrostatic charge or anything else to inhibit it, coagulation follows the law of bimolecular recombination, according to which the rate of disappearance is directly proportional to the square of the concentration (per unit volume) of particles: $dn/dt = -Kn^2$, where K is a constant of proportionality. This equation has the solution

$$1/n - 1/n_o = K(t - t_o),$$

where $n_o$ is the concentration when $t = t_o$. It could not be ascertained whether this treatment is supported by theory or experiment.

8.4. Evaporation of Small Liquid Particles. Langmuir & Schaefer (Reference 20) show that the small particles of a liquid aerosol tend to disappear through evaporation. They show that in small particles the internal pressure necessary to balance the surface tension can be significantly higher than atmospheric pressure. This high pressure induces evaporation. The lifetime, t, of the drop is found to be given by

$$t = \left(\frac{N\rho kT}{M}\right)^2 \frac{r_o^3}{6D\gamma p_o} \qquad (A)$$

where N is Avogadro's number, $\rho$ is the density of the liquid, k is Boltzmann's constant, T is the absolute temperature, M is the molar mass of the substance, $r_o$ is the initial radius of the drop, D is the coefficient of diffusion of the vapor in air, $\gamma$ is the surface tension of the liquid, and $P_o$ is the normal vapor pressure.

At first glance it would seem that the lifetime of the drop increases with temperature. Such is not necessarily the case. For although the surface tension decreases as temperature increases, making for a still greater increase in t, the diffusion coefficient and normal vapor pressure both increase with temperature, counteracting in some cases the upward tendency of t due to the other two factors (T and $\gamma$)

in formula (A). In these cases t actually decreases as T increases. The average particle size of a liquid aerosol can therefore be to some extent controlled through attention to the matter of temperature in its production.

8.5. Total Obscuring Power. (TOP) A quantity used in smoke-screen research for reporting measurements and comparing smoke agents is the Total Obscuring Power (TOP). It is defined as follows. Let c be the concentration by weight of the particulate matter in the smoke. (This is not necessarily the concentration of the dispersed smoke-forming agent, for the agent may oxidize or hydrate upon dispersal.) Let L be the minimum thickness of smoke required to obscure totally the light from a standard light source. Then

$$TOP = 1/cL$$

The significance of TOP will be appreciated after consideration of the Beer-Lambert Law of light attenuation: Consider a beam of parallel rays of light passing through a length L of a light-scattering or - absorbing medium of concentration c. Where $I_o$ and I are respectively the light intensity at the beginning and end of this interval, the relation

$$I/I_o = e^{-qcL}$$

the Beer-Lambert law, holds in a wide range of cases. q is a parameter characteristic of the smoke. Easily,

$$TOP = 1/cL = q/\ln(I_o/I)$$

where the ratio $I_o/I$ is chosen to be the ratio of measured intensities corresponding to the complete obscuration of light from the standard lamp as noted with the unaided eye. Reference 21 takes $I/I_o = 1.25\%$, so that $I_o/I = 80$.

TOP is a practical unit, in that it involves the capacity of a smoke to attenuate light relative to the amount of matter (in terms of weight) in the smoke.

Reference 21 reports the TOP's of many military smokes. See also Section 8.9.

8.6. Spectral Dependence of Transmission. For maximum obscuration, particle diameter is roughly equal to the wavelength of the light.

The earliest successful theory of light scattering was developed by Lord Rayleigh. He showed that the amount of light scattering by a transparent spherical sphere is proportional to the square of its volume and inversely proportional to the fourth power of the wavelength of the radiation. (This fourth-power dependence is often referred to as "Rayleigh scattering.") But for Rayleigh's theory to be applicable to dispersions the particles must be transparent, optically isotropic spheres of diameter less than one twentieth of the wavelength of the incident light, and the dispersion must be sufficiently dilute to preclude interference of the light scattered by the spheres.

The theory developed by Gustav Mie around the turn of the century can be applied to particles that range in size from the region of applicability of Rayleigh's formula up to the region of geometric optics. But the larger the particle size, the more laborious the calculation. An approximation of Mie's formula is

$$I_s = knr^p$$

where $I_s$ the intensity of the scattered light, n is the concentration, r is the particle radius, and k is a constant. The variation of $I_s$ with wavelength is not indicated in this formula. The value of the exponent p is six for Rayleigh scattering and two for very large particles. Values of p have been determined experimentally for particles of a few indices of refraction.

Mie's theory applies only to homogeneous spheres for which the index of refraction is known. According to Reference 17, no satisfactory matematical analysis of light scattering has been made for polydisperse heterogeneous aerosols, such as smoke. The main problem is that of size distribution, which excludes any simple application of the scattering functions for a dispersion of identical particles. Several qualitative features can be noted, however. The absence of distinctive colors in the scattered light indicates heterogeneity. An investigation of the degree of polarization of the scattered light at different scattering angles may give some indication of the size of the particles. And determination of the ratio

of the amount of light passed forward to the amount scattered backward will also give an idea of the size range of the particles.

8.7. Production of Aerosols. The many ways of producing aerosols fall into two categories: the dispersion method and the condensation method. In the dispersion method the particles are introduced into the air already more or less finely divided. In the condensation method the particles are condensed out of a vapor.

These are some dispersion methods: A smoke grenade or bomb can be made by (1) packing a powder around an explosive charge or (2) packing the powder into a container with a gas under pressure, the powder to be released upon rupture of a diaphragm on the container. (3) There are continuous-operation units that force air over or through the compacted powder, so dispersing the particles. (4) Particles can be suspended in a volatile liquid; when the suspension is sprayed into the air, the liquid evaporates, leaving the particles suspended in the air.

A widely used condensation method is based on the condensation of vapors with low vapor pressures. The method consists in vaporizing the smoke-former in a heated stream of gas and then rapidly cooling the hot mixture. In certain vaporizer-condensers used in World War I, hot gas met liquid introduced at the throat of a venturi, atomized it, and subsequently vaporized it in the expanding downstream portion of the venturi. The smoke formed when the gas cooled on mixing with the air after passing out through the nozzle. Only a few pounds per square inch pressure difference was needed to operate the device, and the smoke-formers were hot only for milliseconds -- so that heat-sensitive materials could be used. In other methods the smoke device releases gases into the air which react there and condense into smoke particles. Sections 8. 9 through 8.14 constitute an account of the many kinds of smoke that find use in military operations.

8.8. Weather Conditions and the Use of Smoke. Much of a manual published in 1923 by the British War Office may be out of date, but the material on weather conditions as they effect the laying of smoke screens may still be applicable. (Reference 22)

Best conditions: A wind of 8 to 12 mph (7 to 10 knots), absence of sun, and a high relative humidity are the best conditions for laying a smoke screen.

Unfavorable Conditions: In a gentle and steady wind of less than 4 mph (5 knots) or in a high wind of 25 mph (22 knots) and more, it is very difficult to lay a satisfactory smoke screen, and the large amount of smoke required permits the attempt to be made only in static warfare. When there is no wind, if it is very hot, or when the sun is very bright, it may be impossible to lay a smoke screen.

8.9. Hygroscopic Chemical Smoke Agents. In this and the following sections an abridgement is presented of the extensive account of smoke agents given in Reference 21.

The production of many important smokes depends upon a process wherein the vapors of the chemical agents react with atmospheric moisture to produce the aerosol. The particles are many times the original weight of the chemical agent. Among the chemical agents which depend upon hydrolysis for their effectiveness are the many inorganic chlorides and derivatives of sulfuric acid. Inorganic chlorides that have been used as liquid smoke agents include titanium tetrachloride, silicon tetrachloride, and stannic chloride. Compounds or mixtures containing the oxides of sulfur which have been used for this purpose include sulfur trioxide, chlorosulfonic acid, and oleum. A solution of 55% $SO_3$ with 45% chlorosulfonic acid (by weight) is widely used and is known as FS. Both the sulfur derivatives and the inorganic chlorides have been used as part of a dual smoke agent system in which ammonia or amine derivatives are used either to neutralize the acid produced during the hydrolysis and thus reduce corrosivity and irritation factors, or to form an ammonium chloride solid aerosol.

8.9.1. Agents Based Upon the Hydrolysis of Sulfur Compounds.

8.9.1 .a. FS is a mixture of chlorosulfonic acid ($HClSO_3$) and sulfur trioxide. Each of these chemicals can alone produce an effective screening smoke, but the mixture offers the advantage of improved physical properties. The TOP for $SO_3$ is approximately three times that of $HClSO_3$, and is therefore the principal effective agent. In the presence of water $SO_3$ rapidly forms sulfuric acid, which is highly corrosive to most metals. Most plastics and several types of polyethylene are attacked by the agent as well as by the smoke. FS can be dispersed by mechanical atomization, thermal vaporization, and simple evaporation. It can be disseminated from aircraft spray tanks to produce either an aerial or a ground-based smoke screen. Ground-based smoke screens can also be laid

by dropping the smoke agents in aluminum spheres from aircraft. Upon impact, the spheres break open, thus releasing the smoke agent. The smoke consists of droplets of dilute sulfuric acid admixed with dilute hydrochloric acid and corrodes anything affected by these compounds separately. The smoke is not toxic but is quite irritating to the mucous membranes and the lungs. In appreciable concentrations it causes gagging, probably due to unreacted $SO_3$. In the absence of moisture, FS will not corrode most construction metals. The liquid agent can cause severe skin burns. The standard 45% - 55% mixture used by the U.S. Army has a TOP of 2500, which is high, and has a good persistence.

8.9.1. b. Oleum is a mixture of $SO_3$ in sulfuric acid ($H_2SO_4$). Liquid sulfur trioxide is miscible in all proportions with sulfuric acid, so that the composition and physical properties of oleum can vary considerably. The chemical characteristics of oleum are similar to those of $SO_3$. Its high melting point poses problems for its use in the field, but the use of an oleum mixture high in $SO_3$ content is not uncommon. It is dispersed in a fashion similar to that of FS, and the chemical reactions it undergoes are also similar. The smoke consists of "dilute" sulfuric acid droplets. Oleum corrodes most metals and is therefore, usually stored in glass-lined or stainless-steel containers. The smoke is irritating but non-toxic. It is usually used in the field when supplies of other agents are limited. Oleum is a common intermediate product in the chemical industry and so can usually be obtained in large quantities.

8.9.1.c. Sulfur Trioxide has been widely used for military screening smoke, either along or in conjunction with other chemical agents. Because of its high melting point, $SO_3$ is usually combined with other agents to provide a suitable liquidus range. Smoke formed from pure $SO_3$ has a TOP of about 3000 and has good persistence. The agent is commonly dispersed by thermal vaporization or mechanical atomization. Upon contact with moisture the agent forms sulfuric acid. The dispersed acid particles then absorb more water to produce a cloud consisting of "dilute" sulfuric acid particles. If dry, liquid $SO_3$ does not attack most metals, but it will cause severe skin burns. The smoke is highly irritating but non-toxic. Sulfur Trioxide is a strong dehydrating agent; special precautions should be taken in working with it.

8.9.1.d. Chlorosulfonic Acid can be used either by itself or

with other agents. Smoke is produced by hydrolytic action with atmospheric moisture to form sulfuric and hydrochloric acid particles. These particles then undergo further hydrolysis to produce stable dilute solutions. The smoke corrodes anything affected by these two acids. The TOP reported for chlorosulfonic acid smoke is 1400. The smoke is persistent and non-toxic but is highly irritating to mucous membranes and the skin. Handling and storage problems for the agent are similar to those for FS. Chlorosulfonic acid does not react with mild steel in the absence of water at normal storage temperatures but does attack ferrous metals at elevated temperatures. It is a powerful dehydrating agent on fabrics, wood-fiber, leather, rubber, nylon, and plastics, causing substantial carbonization. Special equipment must be provided for protection against spills and mishandling. Chlorosulfonic acid is often used with sulfur trioxide to make up FS.

8.9.1.e. Sulfuryl Chloride and Pyrosulfuryl Chloride. Sulfuryl chloride $SO_2Cl_2$ is similar to chlorosulfonic acid and sulfur trioxide and is handled and dispersed using the same techniques and equipment as these other materials. It reacts with atmospheric moisture to produce a smoke composed of a combination of sulfuric, sulfurous, and hydrochloric acid droplets. It has a reported TOP of about 1200, roughly equal to that of the better oil fogs, and has good persistence. It is said to cause gagging when inhaled. When heated, it decomposes to sulfur dioxide and chlorine. At ordinary temperatures it does not affect ferrous metals, except in the presence of moisture or at elevated temperatures, when it causes extensive corrosion. Pyrosulfuryl chloride behaves similarly, except that the gas-phase decomposition products at elevated temperatures also include substantial amounts of sulfur trioxide.

8.9.1.f. Mixtures of Sulfur Trioxide and the Sulfuryl Chlorides. Liquid sulfur trioxide is miscible in all proportions with sulfuryl chloride. TOP's for such mixtures are not available. It is assumed that their toxicity, materials compatibility, and general smoke-producing mechanisms are the same or similar to those for FS.

8.9.2. Smoke Agents Based on Inorganic Chlorides. Many hygroscopic chlorides have been used to produce white smoke. The chlorides of the Group-IV elements are the most important of these materials, and titanium tetrachloride, silicon tetrachloride, and stannic chloride have all been used as liquid smoke agents. All three substances are fuming liquids. The

vapors react with atmospheric moisture to produce a complex combination of hydrochloric acid, hydrated metal hydroxides, and metal chlorides. Many other metal chlorides are also efficient smoke agents. Since many of these compounds are normally solids, an external heat source must be provided to vaporize them. Usually this source is a pyrotechnic mixture.

8.9.2.a. Titanium Tetrachloride (FM) is a faint-colored fuming liquid with an acrid ordor. It forms smoke in moist air through a complex series of hydration and hydrolysis products. FM smoke agents are highly hygroscopic and undergo extensive polymerization upon contact with moist air. This polymerization causes extensive clogging of the dissemination equipment, so that cleaning is a major consideration in its use. FM can be disseminated from aircraft spray tanks. The smoke consists of particles of titanium hydroxide, dilute hydrochloric acid, and intermediate products consisting of a complex distribution of the oxychlorides of titanium. Its TOP is 1900 and its persistence is good. The liquid does not corrode metals at ordinary temperatures, provided no moisture is present. It can be stored in containers of steel, aluminum, and other corrosion-resistant metals. The smoke is considerably less irritating and corrosive than FS. While it is generally assumed to be non-toxic under normal conditions, there is evidence that all metal chlorides are somewhat toxic. FM can also be disseminated when dissolved in dichloroethane and similar solvents.

8.9.2.b. Silicon Tetrachloride is less hygroscopic than titanium tetrachloride and so produces little smoke, except when a lot of moisture is available. The smoke particles, produced from the reaction of silicon tetrachloride and water vapor, are probably dilute hydrochloric acid droplets and hydrated silicon oxides. Silicon tetrachloride is less corrosive to metals than titanium tetrachloride. When dry it can be stored in aluminum or steel containers. In the presence of moisture it forms a gummy deposit which clogs equipment. Flesh burns from silicon tetrachloride are similar to those from hydrochloric acid. The smoke has some toxic effects, but the principal difficulty involved in its use is its slow rate of formation of smoke, particularly in dry climates. Its TOP is 1500, and its persistence is good.

8.9.2.c. Chlorides of Tin. The reactions of stannic chloride with water vapor are similar to those of FM. Both stannous and stannic chloride produce smoke, but the smoke formed by the former is considerably less effective than that formed by the

latter. The utilization of stannic chloride is similar to that of titanium and silicon tetrachloride. The smoke is a mixture of HCl droplets and solid particles of the hydrates of orthostannic acid and chloral anhydrides of stannic acid. Its TOP (1850) is somewhat less than that of FM; its persistence is fair. Its corrosive effects are principally associated with the formation of HCl. Upon contact with the skin, stannic chloride produces strong acid burns, and the smoke is reported to be irritating but non-toxic. Operational problems include severe gumming-up of spray equipment and the tendency to react with air and moisture. Corrosivity is assumed to be similar to that of the other liquid metal-chlorides previously described. The smoke is moderately toxic and somewhat irritating.

8.9.2.d. Solid Metal-Chlorides. Many metal-chlorides whose boiling points are not too high can be volatilized by heating and will produce good smokes upon condensation. The heat required for vaporization is usually provided by a pyrotechnic source. The vapor hydrolizes to form HCl and a hydroxide or, in the case of $HgCl_2$, a hydrate of HgO. There are eight such agents: $CuCl_2$ (TOP, low; persistence, low), $FeCl_2$ (TOP, poor; persistence, fair to poor), $FeCl_3$ (poor; poor), $AlCl_3$ (poor; moderate), $ZnCl_2$ (fair; good), $CdCl_2$ (fair to poor; good), $HgCl_2$ (poor; low), $SnCl_2$ (poor; fair to poor).

8.10. White Smokes Containing Phosphorus. Small, highly dispersed droplets of phosphoric acid in air compose the white smokes which have been used for military purposes. The concentration of phosphoric acid in these droplets depends upon the relative humidity. Phosphoric acid is not toxic in dilute concentrations but may cause eye, respiratory, and skin irritations. Phosphorus smokes have a relatively mild corrosive effect on metals but do not attack plastics.

The following method is used to produce phosphoric acid. White phosphorus, red phosphorus vapors, or phosphorus-containing compounds (e.g. phosphines) are burned in air to produce phosphorus pentoxide. Phosphorus pentoxide has an enormous affinity for water, reacting with it to produce phosphoric acid. The high reactivity of phosphorus with oxygen in the air precludes its presence in the resultant smoke. Likewise, the affinity of phosphorus pentoxide for reaction with water vapor makes its presence in the smoke unlikely.

8.10.1. White Phosphorus. The composition of phosphorus is

$P_4$. It produces the most efficient smoke per unit weight. When phosphorus is used to create smoke by a burst-dispersed method, the charge is completely oxidized within seconds of the burst. The smoke formation is accompanied by a sudden release of heat, which brings about an upward rush of air and results in a column-shaped cloud of smoke. The smoke concentration is more than sufficient for effective screening, but its columnar shape detracts from its usefulness as a screening smoke.

Two methods are available for improving its screening application. The heat of combustion can be reduced through the use of compounds or eutectic mixtures containing phosphorus. The other method also involves minimizing the heat of combustion and employs plasticized white phosphorus. One plasticizer used is a viscous rubber solution. The charge burns more slowly and the particles are not dissipated by fusion. The effects of these methods is to preclude the formation of the columnar cloud, thereby extending the effective screening duration.

The obscuring power of white phosphorus is very high, with a TOP of 4600. The persistence is good, and the toxicity, corrosivity, and irritation are low.

Other methods of producing phosphorus-containing smokes include (1) the dispersion of phosphorus in a solvent, such as methylene iodide or carbon disulphide; (2) the reaction of phosphorus trichloride with ammonia and amines to produce an irritating, non-toxic smoke composed of complex mixtures of amino-phosphorus chlorides and amonium chloride; and (3) the dispersion of phosphorus sulfides in carbon disulfide, which easily burns in air and ultimately produces a relatively harmless smoke composed of phosphorus and sulfurous acids.

A smoke agent composed of 33% methylene iodide and 66% white phosphorus yields a smoke with a TOP of 2800. Its persistence is good, while its toxicity, corrosivity, and irritation are moderate.

The smoke formed with phosphorus pentasulfide ($P_2S_5$) has the following properties. The obscuring power and corrosivity are moderate, and the persistence is good. Toxicity and irritation are both low.

When phosphorus sesquisulfide ($P_4S_3$) is used as a smoke agent, the resultant smoke has a high obscuring power and good persistence. Its corrosivity is moderate, while its toxicity and irritation are low.

8.10.2. Phosphorus & Phosphorus Sesquisulfide Mixture. This eutectic mixture is composed of 55% white phosphorus and 45% phosphorus sesquisulfide by weight. It is a clear, yellow light-sensitive oil of medium viscosity and low surface tension.

The mixture is pyrophoric in air and can be safely stored for several days under water in the dark.

The smoke produced from this eutectic mixture has a high obscuring power with a TOP of 2800 to 3000. Its persistence is good, and its toxicity, corrosivity, and irritation are low.

8.11. Organo-Metallic Compounds. A number of organo-metallic compounds can be used to make smoke. They are pyrophoric in air and burn to produce metal oxides and hydroxides. The smoke is non-irritating and, depending upon the metal, may be non-toxic.

8.11.1. Dimethyl Zinc compounds have been used to make smoke. The smoke may consist of solid zinc hydroxide particles. Its toxicity is low, and it is expected to be low in corrosivity. As far as can be determined, its TOP is low. Major problems are involved in handling the agent because of its pyrophoricity.

8.12. Smokes Formed by Vaporization and Condensation.

8.12.1. Fog Oils. A very satisfactory white screening smoke can be produced by vaporization and condensation of an oil that has a high boiling point and a low volatility. Relatively complex devices must be used to provide the heat necessary for evaporation and the flow of air necessary to produce condensate particles of closely controlled size. The toxicity, handling, and materials compatibility of these oil smokes are all excellent.

8.12.2. Intimate Oil Smokes. The only alternative to the complexity involved in the use of fog oils is to use an intimate oil mixture, which is a smoke agent in which a fuel is incorporated into a fog oil or hydrocarbon system. The fuel burns in the air, releasing heat which vaporizes the oil.

The ideal mixture is one in which the fuel is oxidized upon contact with the air.

8.12.3. Sulfur Smokes consist of small particles of elemental sulfur. They can be produced by methods similar to those used to produce oil smokes. They can also be made from intimate mixtures of sulfur and a suitable fuel. Three such mixtures are sulfur, sodium nitrate, and charcoal; sulfur, potassium nitrate, and charcoal; and sulfur, ammonium nitrate, and charcoal. The sulfur is present in much larger quantities than in black gunpowder. The burning of the fuel is slowed down through the absorption of heat in melting and vaporizing the sulfur.

8.13. Smokes Formed Upon the Dispersal of Solid Particulate Matter. A number of powders have found use in setting up military smoke screens. To persist, they must be of uniform size in the range 1 to 10 microns. If the particles are much larger than this, they tend to fall out rapidly. Because the particles do not usually react with atmospheric gases to produce larger amounts of bound material, their TOP's can be no greater than those of the best oil fogs. Their upper limit is about 1200. As the materials are inert, the smokes are completely non-toxic and non-corrosive. The major disadvantages involved in their use are their low TOP's and the difficulty in producing uniform dispersal at ground level.

8.14 Dual Smoke Agents can form better smokes. The enhanced effectiveness arises either from improved TOP's or from reduction in corrosiveness or toxicity. These improvements can outweight the major disadvantage of increased problems with equipment and handling. The high corrosiveness of FS, for instance, can be suppressed, at no reduction of TOP, by the addition of a weak base capable of combining with the dilute acids formed in the hydrolysis of the agent in moist air. Ammonia or an amine derivative will serve this purpose. The smoke also becomes less irritating. Some dual agents enhance obscuration by forming fine particles.

8.14.1. Sulfur Trioxide and Ammonia or Amines. The smoke is formed by supplying ammonia or an amine to sulfur trioxide at the time of dispersal.

8.14.2. Chlorosulfonic Acid and Ammonia or Amines. Ammonia and the amines react readily with chlorosulfonic acid in much the same fashion as with sulfur trioxide.

8.14.3. Titanium Tetrachloride and Ammonia. The system is most effective when the reactions take place in the presence of water vapor. The smoke is a mixture of $Ti(OH)_4.H_2O$, intermediate hydroxy chlorides of titanium, and ammonium chloride particles.

8.14.4. Silicon Tetrachloride, Ammonia, and Water. The best proportions are two parts silicon tetrachloride, one part ammonia, and one part water, by weight.

8.14.5. Hydrochloric Acid and Ammonia. The reaction of hydrochloric acid with ammonia is similar to the reaction of a metal chloride with ammonia. This system produces fine particles of solid ammonium chloride. Gaseous hydrochloric acid is not very corrosive to metal containers when dry, but it is quite corrosive in the presence of water. It is highly irritating and toxic in moderate amounts. Ammonia gas is also toxic in moderate amounts. The smoke is not corrosive to metals, nor is it toxic.

8.14.6. Sulfur Compounds and Ammonia. Sulfur compounds react with bases, including ammonia and the amines. These smoke-producing systems do not require atmospheric constituents to form smoke and may therefore be useful at high altitudes. Their TOP's are relatively low.

8.14.7. Sulfur Chloride and Ammonia. This system has not been widely used. Little information is available concerning its chemical reactions, handling properties, and corrosiveness.

8.14.8. Sulfuryl Chloride and Ammonia or Amines. Sulfuryl chloride ($SO_2Cl_2$) reacts with bases such as ammonia and the amines to produce a better smoke than that formed with water vapor. The dispersed phase consists of ammonium chloride with sulfamide, iminosulfamide, and trisulfamide. When the air is exceedingly humid, ammonium sulfate is also produced. Because of the low TOP of the smoke, this agent has not seen extensive use.

## APPENDIX. LAYING OUT DISRUPTIVE SCHEMES

On page 46 of his book Camouflage Simplified (Ref. 10), Eric Sloane describes a procedure for laying out disruptive schemes on surfaces. The procedure is based upon a practice of advertising layout men of drawing all the diagonals of the area to be exploited, connecting with straight lines all the points of intersection of these diagonals, and then using the two sets of lines thus drawn as the basis for the advertising design. It is asserted that these lines are "in harmony" with the shape of the layout area and that anything drawn along them is also in harmony with the area and will accentuate its shape. Designs that do not follow this system "therefore" do not harmonize with the shape of the area and will tend to disrupt it.

## LIST OF PERTINENT SPECIFICATIONS

NOTE. The Basic Index mentioned in connection with some of the specifications is the Index of Department of Defense Specifications and Standards, published on July 31st of the year indicated.

Anodic Coatings, for Aluminum and Aluminum Alloys. MIL-A-8625B.

Asphalt, Cut-Back (for) Road-Work. SS-A-671A.

Asphalt, Petroleum, Waterproofing Compound ; Colors, Container Sizes, and Use Characteristics therof. MS-35651(CE).

Brick, Paving. SS-B-671c.

Camouflage Net Drape Sets, Packaging of. MIL-C-11782C.

Camouflage Net Set, Anti-Aircraft Machine Gun. MIL-C-3439A.

Camouflage Net Set, No. 4, M2. MIL-C-20185. Rescinded.

Camouflage Net Set, No. 5. MIL-C-20186. Rescinded.

Camouflage Net Set, No. 6, M2, Single-Engine Airplane. MIL-C-20187. Rescinded.

Camouflage Net Set, No. 7, M2, P-38 Type Airplane. MIL-C-20186. Not in 1965 Basic Index.

Camouflage Training Set, Company, Packaging of. MIL-C-11406C.

Candle, Smoke, Oil, SGF2, M6; Components for. MIL-C-11136A(Cml C). Rescinded December 1, 1966. Superseded by MIL-S-11141, Smoke, Pot, Oil, SGF2, M6.

Cases, Carrying, Cotton-Duck, for Pneumatic Decoy Targets. MIL-C-52014A(ME).

Chemical Agent, Mustard, Simulated (Molasses Residuum). MIL-C-10856D.

Chemical Films and Chemical Film Materials for Aluminum and Aluminum Alloys. MIL-C-5541A.

Clip, Spring, Camouflage, Armored Vehicle, for 120-mm, 90-mm, or 76-mm Gun Barrel. MIL-C-12073C(ME).

Cloth, Ballistic, Nylon. MIL-C-12369D(GL).

Cloth, Burlap, Jute (or Kenaf). CCC-C-467b.

Cloth, Camouflage: Impregnated, Flame-Resistant; Osnaburg and Burlap; 100-yard rolls. MIL-C-765B(4).

Cloth, Cellulose Acetate Butyrate, Predoped Airplane. MIL-C-5642A.

Cloth, Coated (for Aircraft Protectors). MIL-C-19524(2).

Cloth, Coated, Nylon, Polyvinyl Butyral. MIL-C-14366B.

Cloth, Coated, Nylon, Waterproof. MIL-C-20696A (2).

Cloth, Coated, Vapor Permeable, Water Impermeable. MIL-C-19208A. Rescinded.

Cloth, Cotton, Airplane Curtain. MIL-C-9336(1).

Cloth, Cotton, Balloon. MIL-C-12318A.

Cloth, Cotton, Netting. MIL-C-9278(USAF).

Cloth, Cotton, Sheeting (Unbleached, Bleached, and Dyed). CCC-C-432B.

Cloth, Duck, Cotton, Unbleached, Plied-Yarns, Army and Numbered. CCC-C-419b.

Cloth, Laminated, Cotton, Balloon, 3 Ply, Air Retaining, Chloroprene. MIL-C-11390C(GL).

Cloth, Osnaburg, Cotton. CCC-C-429b.

Coating, Compound, Bituminous Emulsion; Colors, Container Sizes, and Use Characteristics thereof. MS-35504(CE).

Coating, Onide, Black, for Ferrous Metals. MIL-C-13924B.

Coating Compound, Bituminous, Emulsion Type, Coal Tar Base. MIL-C-15203C(DOCKS).

Coating Compound, Bituminous, Solvent, Coal Tar Base. MIL-C-18480A(DOCKS).

Coating Compound, Bituminous, Solvent; Colors, Container Sizes, and Use Characteristics thereof. MS-35505(CE).

Coating Compound, Bituminous, Solvent (for Railway Rolling Stock). MIL-C-13950(CE).

Coating Compound, Luminescent, Phosphorescent. MIL-C-4996A(ASG).

Coating Compound, Metal-Pretreatment, Resin-Acid. MIL-C-8514B(1)(ASG).

Coatings, Protective; Application of to Fabric Surfaces of Aircraft. MIL-C-18187A(ASG).

Colors. Federal Standard #595.

Colors. MIL STD 795 Change 1 (26 Aug 1964.)

Colors; (for) Ready-Mixed Paints. TT-C-595. Superseded by FED STD 595 (Colors).

Colors, List of Standard Aircraft Camouflage. ANA 157 REV-E.

Colors; List of Standard Aircraft Glossy. ANA 166e.

Core Material, Foamed-in-Place, Polyester Diisocyanate, Type (ASG). MIL-C-8087B.

Cover, Helmet, Camouflage. MIL-C-17502A.

Decoy Target, Bailey Bridge, Double Double. MIL-D-52165(CE).

Decoy Target, F-86 Aircraft, Type MC-2. MIL-D-26049A. Not in 1966 Basic Index.

Decoy Target, Gun, Anti-Aircraft: Self-Propelled, 40mm. MIL-D-52048/9(CE).

Decoy Target, Gun: Field Artillery, Towed, 155-mm. MIL-D-52048/2(CE).

Decoy Target, Howitzer: Light, Towed, 105-mm. MIL-D-52048/3(CE).

Decoy Target, Howitzer: Medium, Towed, 155-mm. MIL-D-52048/1(CE).

Decoy Target, Howitzer, Self-Propelled, 105-mm. MIL-D-52048/10(CE).

Decoy Target, Tank: Combat, Fall-Tracked, Medium 76-mm Gun, M41. MIL-D-52048/4(CE).

Decoy Target, Tractor: Full-Tracked, High Speed, M5. MIL-D-52048/6(CE).

Decoy Target, Tractor: Full-Tracked, High Speed, M8A1. MIL-D-52048/5(CE).

Decoy Target, Truck, Cargo, 2 1/2 ton, 6 x 6, M34. MIL-D-52048/7(CE).

Decoy Target, Truck: Wrecker; Medium, 5-ton, 6x6, M62, w/Winch, w/E. MIL-D-52048/8(CE).

Decoy Targets, Low Fidelity, Pneumatic, General Construction Material for, Packaging. MIL-D-52048.

Disperser, Riot-Control Agent, Helicopter-or Vehicle-Mounted, M4. MIL-D-51032(1)(MU).

Dope, Cellulose-Acetate-Butyrate, Pigmented, Camouflage. MIL-D-5550A.

Dope, Cellulose Nitrate, Pigmented, Camouflage. MIL-D-5555(1).

Doping Aircraft Surfaces, General Specification for. MIL-D-8096(USAF).

Drape Pattern. MIL-N-763. Not in 1966 Basic Index.

Drier, Paint, Liquid. TT-D-65le.

Dyeing and After-Treating Processes for Cotton Cloths. CCC-D-950c.

Dyeing and Aftertreating Processes for Cotton Fabrics. CCC-D-00950A. Rescinded.

Enamel; Beach-Sand, Semigloss Formula No. MSTS-3. MIL-E-17136B(SHIPS).

Enamel, Camouflage, Quick Drying. MIL-E-5556B(2).

Enamel, Camouflage, Solar- and Heat- Reflecting. MIL-E-46061(1).

Enamel, Exterior, White, Vinyl-Alkyd (Formula No. 112-82). MIL-E-16738B(1).

Enamel, Lusterless, Quick-Drying (for Ammunition). MIL-E-10687. Not in 1966 Basic Index.

Enamel, Lustreless, Solar Heat Reflecting, Olive Drab. MIL-E-46096A.

Enamel, Olive Drab, Lusterless, for Polychloroprene-Coated Fabric. MIL-E-13072A.

Enamel, Quick Drying, Camouflage, Colors, Container Sizes, and Use Characteristics Thereof. MS-35727. Rescinded.

Enamel, Ship, Exterior, Alkyd, White (Formula No. 6). MIL-E-1264C.

Enamel, Textured, Olive Green (for Coating Liners, Helmet M-1). MIL-E-2052A.

Enamel, White (Formula 30) (for Naval Shipboard Use). MIL-E-1115A.

Enamel, Wrinkle-Finish, for Aircraft Use. MIL-E-5558A.

Enamel, Wrinkle-Finish, for Aircraft Use, Application of. MIL-E-7851.

Environmental Testing, Aeronautical and Associated Equipment, General Specifications for MIL-E-5272c(1)

Generator, Smoke, Mechanical, Pulse Jet, ABC-M3A3. MIL-G-51066A.

Generator, Smoke, Mechanical Pulse Jet, ABC-M3A3. (Used in Lieu of MIL-G-51066A). MIL-G-0051066B.

Grenade, Hand, Incendiary TH3,AN-M14. MIL-G-12297 D(MU).

Grenade, Hand, Smoke, HC, AN-M8. MIL-G-12327D.

Grenade, Hand, Smoke, HC, AN-M8 (used in Lieu of MIL-G-12327C). MIL-G-0012327D(1).

Grenade, Hand, Smoke (H.C.), M8 - Metal Parts for. MIL-G-20438.

Grenade, Hand, Smoke, M18. MIL-G-12326F(2).

Grenade, Hand, Smoke, WP, E2R39. MIL-G-12247(CmlC).

Grenade, Hand, Smoke, WP, M15. MIL-G-12237B.

Grenade, Hand and Rifle, Smoke, WP, M34. MIL-G-46690B (MU).

Grenade, Hand and Rifle, Smoke, WP, M34, Inert Components. MIL-G-46693B(MU).

Grenade, Rifle, Smoke, Colored, M22Al, Metal Parts for. MIL-G-11164(Ord).

Grenade, Rifle, Smoke, Colored Streamer, M23Al, Assembling, Marking and Packing. MIL-G-20435A.

Grenade, Rifle, Smoke, Colored Streamer, M23Al, Metal Parts for. MIL-G-11248(ORD).

Gun, Portable Riot Control Agent Disperser, M9. MIL-G-51025F.

Hood, Blackout - Medium Intensity Runway Light. MS-27038B.

Hood, Field Protective Mask, M6. MIL-H-51166A(MU).

Hood, Winter, Cotton, Olive Green, M-1951. MIL-H-11377D.

Hood, Winter, Cotton Warp, Nylon Filled, Oxford, OG-107, w/ Fur ruff. MIL-H-11023D.

Hood, Winter, Knit, Wool. MIL-H-25754A(USAF).

Identification Marking of Administrative, Combat and Tactical Transport Vehicles. MIL-STD-642F.

Identification Marking of U.S. Military Property. MIL-STD-130B(1).

Indicator, Humidity, Card, Three-Spot, Impregnated Areas (Cobaltous Chloride). MS#20003

Ink, Marking, Stencil, Opaque, for Non-Porous Surfaces (Metals, Glass, etc.). TT-I-558B.

Ink, Marking, Stencil, Opaque, for Porous Surfaces (Wood Boxes, Fiber Cartons, etc.). TT-I-559B(2).

Lacquer, Acrylic-Nitrocellulose, Camouflage (for Aircraft Use). MIL-L-19538B(1)(ASG).

Lacquer, Camouflage. MIL-L-6805. Rescinded. Replaced by Lacquer Camouflage (TT-L-20).

Lacquer, Cellulose Nitrate, for Aircraft Use, Application by Hot-Spray Process (ASG). MIL-L-8645A (ASG).

Lacquer, Lusterless. MIL-L-73A(1).

Lacquer, Lustreless, Hot Spray. MIL-L-11195C.

Lacquer, Lusterless, Obliterating. TT-L-40.

Lacquer, Multicolor, Aqueous, Dispersion Type (for Spray Application). TT-L-45b.

Lacquer (Enamel), Nitrocellulose and Acrylic, Aerosol Halogenated Hydrocarbon (in Pressurized Dispensers). TT-L-50D(INT. AMD.1).

Lacquer Camouflage. TT-L-20. Supersedes Lacquer, Camouflage. (MIL-L-6805).

Liners, Case, and Sheet, Overwrap, Water-Vaporproof or Waterproof Flexible. MIL-L-10547B(3).

Luminescent Material, Fluorescent. MIL-L-25142(ASG).

Luminescent Material and Equipment (Non-Radioactive). MIL-L-3891A(2).

Mats, Landing, Airfield, AM2. MIL-M-81345.

Mats, Landing, Pierced-Plank Type. MIL-M-59C(1).

Mildew Resistant Compound, Textile (for Field Treatment). MIL-M-13295B.

Mixer, Plaster and Mortar, Trailer Mounted, Gasoline-Engine Driven. MIL-M-22957A.

Naphtha; Aromatic. TT-N-97b.

Net, Camouflage, Fiber: Cotton. MIL-N-568C.

Net, Camouflage, Fiber, Cotton-Twine, with Hardware and Fabric Garnishment, for Drape Sets. MIL-N-11849B (1).

Net, Camouflage, Fiber, Garnished with Fabric, Flat Top and Drape Patterns. MIL-N-763B.

Net, Multipurpose. MIL-N-43181(2).

Netting, Camouflage, Wire, Steel, Fabric-Garnished. MIL-N-52136.

Netting, Camouflage, Wire, Steel, Feather-Garnished. MIL-N-52095(1).

Netting, Camouflage, Wire, Steel, Glass-Fiber-Garnished. MIL-N-52154(1).

Netting, Camouflage, Wire, Steel, Steel-Wool Garnished. MIL-N-52135(1).

Netting, Camouflage, Wire, Steel, Straightline Woven, Zinc-Coated. MIL-N-586B.

Paint, Oil, Ready-Mixed. MIL-P-630A.

Paint, (Outside, Dull Black Formula No. 104). MIL-P-15146A.

Paint, Camouflage or Temporary Identification, Solvent-Removable (Use in Lieu of MIL-P-6884). MIL-STD-6884C. Possibly rescinded.

Paint, Deck, Black. MIL-P-698A.

Paint, Face, Camouflage, Stick Form. MIL-P-2018C.

Paint, Fluorescent, for Aircraft, Process for Application of. MIL-P-21698A.

Paint, Graphite, Outside, Ready-Mixed, Black. TT-P-27.

Paint, Heat-Resisting, Olive Drab (for Steel Surfaces). MIL-P-14105A(CE).

Paint, Oil, Ready-Mixed. MIL-P-630A(MO).

Paint, Phosphorescent, Ready-Mixed (Non-Radioactive). TT-P-54a.

Paint, Striping, Green (Formula No. 39). MIL-P-2854.

Paint, Temporary, Lusterless, Gasoline Removable. MIL-P-13983C(1).

Paint, Temporary Identification Camouflage. MIL-P-6884B.

Paint, Traffic; Reflectorized for Airfield Runway Marking (Drop-In Type). TT-P-85b (INT. AMD. 3).

Paint, Traffic Black (Nonreflectorized). TT-P-110b.

Paint, Varnish, Lacquer, and Related Materials; Methods of Inspection, Sampling, and Testing. Fed. Test Method Std. No. 141a.

Paint, Water, Paste (for Camouflage Use). MIL-P-13340A.

Paint, Water Emulsion Type (for Stenciling and Obliterating). MIL-P-52108A(MR).

Paint System, Fluorescent, for Aircraft Application (ASG). MIL-P-21563B.

Paint System, Fluorescent, Removable, for Aircraft Application. MIL-P-21600A.

Painting, Freight and Maintenance Cars. MIL-P-3320C.

Painting: Railway Motive Power and Work Equipment. MIL-P-3321C(1).

Painting, Steel-Hull Harbor Craft. MIL-P-3846B.

Painting Procedures, Tactical Vehicles (Tracked and Wheeled). MIL-STD-193E.

Parka, Man's, Camouflage, Overwhite, M-1950. MIL-P-10809C.

Parka, Man's CWU-8/P. MIL-P-38184A(2)(USAF).

Parka, Man's, M-1951. MIL-P-11013D.

Plastic Materials, Polyester Resin, Glass Fiber Base, Low Pressure Laminated. MIL-P-8013C(1).

Plastic Sheet, Cast Acrylic, Colored and White, Heat Resistant, Shipboard Lighting Application. MIL-P-17962B. Rescinded.

Plastic Sheet, Phenolic, Glass Fabric Reinforced, Heat Resistant. MIL-P-46040A.

Plywood, Flat Panel. NN-P-530B.

Poncho, Lightweight with Hood. MIL-P-3003G.

Poncho Assembly. MS-22051(Aer).

Pot, Smoke, HC, M1; Components for. MIL-P-10631B.

Preservation, Methods of. MIL-P-116E. Int. Amd. 1 (EL).

Primer and Enamel, Coal Tar. MIL-P-15147C.

Prrimer Coating, Alkyd, Wood, and Ferrous Metal. TT-P-636c.

Primer Coating, Cellulose-Nitrate Modified Alkyd Type, Corrosion-Inhibiting, Fast-Drying (For Spray Application Over Pretreatment Coating). MIL-P-7962B (ASG).

Primer Coating; Phenolic, Water Immersible. MIL-P-12742B.

Primer Coating, Zinc Chromate, Low-Moisture-Sensitivity. MIL-P-8585A.

Protective Finishes. L MIL-HDBK 132.

Regulator. Compressed Air, High Pressure (3.500 psi). MIL-R-23057 (Wep.).

Sampling Procedures and Tables for Inspection by Attributes. MIL-STD-105D.

Sealer, Surface. Wood Preservative. MIL-S-13518B.

Shellac Cut, Pigmented, Green, Formula No. 25. MIL-S-18000 (Ships).

Shelter, Aircraft Maintenance, Type B-4. MIL-S-5137A. Recinded.

Shelter, Field Maintenance, Type A-1A. MIL-S-4049. Not in 1966 Basic Index.

Shelter Half, Tent. MIL-S-3725B (2).

Simulator, Antenna SM-60/ASB-1. MIL-S-17643(1).

Simulator. Atomic Explosion, M142 Parts for and Loading. Assembling and Packing. MIL-S-46528B(MU).

Simulator, Booby Trap, Flash, M117/Loading, Assembling and Packing. MIL-S-10521E.

Simulator, Booby Trap, Illuminating M118, Parts for, and Loading, Assembling and Packing. MIL-S-10555D(1).

Simulator, Booby Trap, Whistling, M119, Loading, Assembling, and Packing. MIL-S-10522F(1).

Simulator, Echo Ranging, SSQ-15. MIL-S-82312(ONR/NTDC).

Simulator, Guided Missile SM-159/DSM. MIL-S-22006A(Wep.).

Simulator, Guided Missile, SM-161/DSM (Tartar). MIL-S-22537.

Simulator, Gunfire, Small Arms. MIL-S-82328(ONR/DTDC).

Simulator, Gunflash, M110/Parts and Loading, Assembling and Packing. MIL-S-20441A(MU)(1).

Simulator, Hand Control SM-214A/APQ-83. MIL-S-22645B(WEP).

Simulator, Hand Grenade, M116A1/Parts for, and Loading, Assembling and Packing. MIL-S-10057F(MU).

Simulator, Launcher and Missile/Mark 6 Mod. 2. MIL-S-81127(Wep.).

Simulator, Machine-Gun Fire, and Simulator, Rifle Fire, .30 Caliber. MIL-S-52233(CE).

Simulator, Projectile, Air Burst, M27A1B1, Parts, and Loading, Assembling and Packing. MIL-S-20488A(2)(Ord.).

Simulator, Projectile/Air Burst M74A1/Loading, Assembling and Packing. MIL-S-20517C(1)(Ord.).

Simulator, Projectile, Ground Burst, M115A2/Loading, Assembling, and Packing. MIL-S-10058D(1).

Simulator, Projector, Pyrotechnic Airborne. MIL-S-52117(CE).

Simulator, RAWIN Set SM-131( )/GMD. MIL-S-55105(Sig.C).

Simulator Recognition Signal, SM-140( )/TPX.
MIL-S-55160(Sig. C).

Simulator Group AN-GLA-18. MIL-S-27879(1) (USAF)

Simulator Set, Countermeasures Signal AN/FLA-4( ).
MIL-S-27109A.

Simulators, Artillery, Mine and Demolition Noise.
MIL-S-82337(ONR/NTDC).

Smoke Pot, Floating, SGF2, AN-M7A1. MIL-S-51235(MU).

Smoke Pot, Oil, SGF2, M6. MIL-S-11141D(MU).

Smoke Pot, 30-Pound, HC, M5. MIL-S-13183B.

Smoke Pot, 30-Pound, HC, M5; Components for.
MIL-S-3793B.

Smoke Tank, Airplane, M10. MIL-S-13610A.

Spray Outfit, Paint, Bituminous Emulsion, Trailer-Mounted, with Compressor and Gasoline Engine.
MIL-S-3050B.

Spray Outfit, Paint, Portable, Power Driven, Cart Mounted with Compressor. MIL-S-45834(CE).

Spray Outfit, Paint-Gasoline Engine Driven-Hand Truck Mounted (Trailer and Wheelbarrow Types). MIL-S-18643A.

Sprayer, Emulsion, Drum Mounting. MIL-S-23436(DOCKS).

Surface Treatments and Metallic Coatings for Surfaces of Weapons Systems. MIL-S-5002A. Int. Amd. 1 (11)

Tank, Spray, Dry Agent A/B45Y-2. MIL-T-38600A(USAF).

Tent, Arctic, 10 Man. MIL-T-12354B.

Tent, Assembly, M-1942. MIL-T-1110C.

Tent, Command Post, M-1945, Fire, Water, Weather and Mildew Resistant, Olive Drab, Complete. MIL-T-1111C. (Int. Amd. 1.)

Tent, Frame Type, Aviation Maintenance, Small. -MIL-T-43189(GL).

Tent, Frame Type, Balloon Inflation M-1957, fire. Water, Weather and Mildew Resistant, Olive Drab, Complete. MIL-T-12685C.

Tent, Frame Type, Insulated, Sectional, with Floor, 16 Feet Wide, M-1948, Complete. MIL-T-10168F.

Tent, General Purpose, Large. MIL-T-14038D. Int. Amd. 2 (GL).

Tent, General Purpose, Medium. MIL-T-1712H (1) (Int. Amd. 4 (GL)).

Tent, General Purpose, Small. MIL-T-41810C (Int. Amd. 1)

Tent, Hatch Type, Fire, Water, Weather and Mildew Resistant, Olive Drab. MIL-T-13056D(GL).

Tent, Hexagonal, Lightweight M-950. MIL-T-10035E.

Tent, Kitchen, Flyproof, M-1945 Fire, Water, Weather, and Mildew Resistant, O. D., Complete. MIL-T-10009D

Tent, Maintenance Shelter, Fire, Water, Weather and Mildew Resistant, Olive Drab. MIL-T-10069D (Int. Amd. 1).

Tent, Mountain, Two-Man, Complete with Pins and Poles. MIL-T-1926E.

Tent, Pontoon Barge Type, Cloth, Cotton Duck. -Mil-T-19324(DOCKS).

Tent, Vehicle Maintenance, Complete with A-Frame. MIL-T-41830A.

Tent and Sleeve, Console, Track Antenna Equipment, Complete with Frame. MIL-T-41811.

Tent Sections, Frame Type, Maintenance, Medium. MIL-T-41813B.

Thermit Burning Charge MK 1. MIL-T-18508(NOrd). Rescinded.

Thinner, Acrylic-Nitrocellulose Lacquer. MIL-T-19544B(ASG).

Thinner, Celluose Acetate Butyrate Dope. MIL-T-6096A.

Thinner; Dope and Lacquer (Celluose Nitrate). TT-T-266b.

Thinner; Paint, Volatile Spirits (Petroleum-Spirits). TT-T-291c.

Toluene; Technical. TT-T-548c.

Treatment and Painting of Materiel. MIL-T-704D.

Varnish; Asphalt. TT-V-51c.

Webbing, Textile, Woven Nylon. MIL-W-4088E (2) Int. Amd. 3 (GE).

Webbing and Tape, Textile and Cotton, General Purpose, Natural or in Colors. MIL-W-530D(2).

Wire Fabrics; Steel, Welded. MIL-W-585C.

Wood, Preservation: Treating Practices. TT-W-571g.

## ABSTRACTS OF SELECTED SPECIFICATIONS

### 1. ARTIFICIAL COVER

**CAMOUFLAGE NET SET, Antiaircraft Machine Gun. MIL-C-3439A. 1959** -- Collapsible. For the 50-caliber antiaircraft machine gun. Consists of camouflage garnished nets, supporting ribs, pivot and net stakes, and necessary attachments. Accessoriesprovided with each set: a sledge hammer, a stake-driving cap, and a carrying bag for the nets. The nets are the same as in military specifications MIL-N-763B (Net, Camouflage, Fiber, Garnished with Fabric, Flat Top and Drape Patterns), described below, except that the garnishing patterns and density are different, as prescribed in separate drawings.

**CAMOUFLAGE NET SET, No. 5. MIL-C-20186. 1951** -- Rescinded June 17, 1965.

**CAMOUFLAGE NET SET, No. 6 M2, Single-Engine Airplane. MIL-C-20187. 1951** -- Rescinded June 17, 1965.

**CLOTH, Burlap, Jute (or Kenaf). CCC-C-467b. 1965** -- Burlap is cloth made of a coarse vegetable fiber. These specifications call for the use of jute of kenaf or any combination thereof. Jute is the bast fiber obtained from an East Indian plant, genus Corchorus, of the linden family. Kenaf is the bast fiber obtained from the East Indian ambary plant (Hibiscus cannabinus), of the mallow family. Ambary and kenaf are often used interchangeably. There are four classes of burlap specified, of varying mesh density: class 1 -- 6.7 ounces per square yard or 7.5 ounces per yard of 40-inch-width roll; class 2 -- 7.2 oz/sq yd or 8 oz/yd of roll; class 3 -- 9.0 oz/sq yd or 10 oz/yd of roll; class 4 -- 10.8 oz/yd$^2$ or 12 oz/yd of roll. The length of continuous rolled cloth is to be at least 25 yards.

**CLOTH, Camouflage, Impregnated, Flame-Resistant; Osnaburg and Burlap; 100-yard Rolls. MIL-C-765B(4). 1966** -- Intended to be used for camouflage cover and camouflage net garnishing. Osnaburg and burlap are defined under the appropriate specifications (Cloth, Osnaburg, Cotton, CCC-C-429b; Cloth, Burlap, Jute (or Kenaf), CCC-C-467b). The raw cloth is impregnated with pigments as specified. The raw cloth for Type 1 impregnated cloth is Osnaburg, Type II, class 2, finish A. (These specifications, although promulgated in 1966, do not take cognizance of the fact that since 1964, specifications have been in force

for only one type and three classes of Osnaburg.) Type II impregnated cloth is burlap. Both can be colored light green (color No. 1), dark green (color No. 2), sand (3), field drab (4), earth brown (5), earth yellow (6), earth red (8), olive drab (9), forest green (12), and desert sand (13). In addition, type I is specified for white (11), and type II is specified for black (10). These colors are not designated using Federal Standard No. 595 (Colors) but using polygons (hexagons) in a chromaticity diagram.

Military Standard MIL-Std-795 (1962) provides chromaticity values for only about three-quarters of the lusterless colors presented in Federal Standard No. 595 (as amended in 1960), so that only seven colors in that standard (each color being specified by only one set of chromaticity values rather than by a range of values) could be placed within the chromaticity polygons governing the colors the camouflage cloth may be ordered in: Color #30277 of Fed. Std. 595 falls within the chromaticity hexagon for Color No. 2 (sand); #30118 (sometimes called Dark Earth) -- Color No. 4 (field drab); #30099 -- No. 5 (earth brown); #30117 -- No. 7 (earth red); #17886 (glossy white) -- No. 11 (white); #34079 (also called Shadow Green) -- No. 12 (forest green); #30324 -- No. 13 (desert sand).

Maximum and minimum infrared reflectivities are specified for all cloth colors, and maximum and minimum red reflectivities are given for olive drab and the three greens. In the latter case the minimum allowable ratios between infarared and red reflectivities are also specified, Infrared reflectivity is determinded by averaging the reflectance percentages measured at each of the thirty wavelengths 714.5, 724.7, 731.4, 737.0, 742.3, 746.8, 751.3, 755.7, 760.0, 764.3, 768.7, 773.0, 777.4, 782.8 787.3, 792.7, 797.2, 801.6, 806.6, 811.3, 816.2, 821.1, 826.0, 831.1, 836.0, 842.1, 848.0, 854.5, 862.2, and 873.0 millimicrons. Red reflectivity is determined by averaging the reflectance percentages measured at each of the ten wavelengths 626.5, 638.0, 645.3, 649.0, 651.5, 653.5, 655.5, 658.5, 663.0, and 669.6 millimicrons. The treated cloth is to come in 100-yard rolls of 2- to 2 1/4-inch and 40-inch widths. The weight increase after impregnation is to be no more than 55% over the weight of the raw cloth for all colors, except olive drab and the greens, for which a maximum increase of 65% is allowed.

**CLOTH, Coated (for Aircraft Protectors). Mil-C-19524(2) (Wep).** 1962 -- A coated cloth intended to be fabricated into protective covers for covering parts (wings, tail groups, rotor parts, etc.) of aircraft standing by in "adverse weather conditions of ice, snow, frost, etc." The cloth is coated on both sides with suitably compounded polymer or copolymer ethylene resins, the color an option of the procuring agency, to come in rolls 36±1/4 inches wide and 200 yards long. The weight of the coated cloth is to be 4 to 9 ounces per square yard.

**CLOTH, Coated, Nylon, Waterproof. MIL-C-2069A(2).** 1966 -- Two types and three classed of vinyl- or chloroprene-coated nylon fabrics to be used in the fabrication of "equipage items" and covers for wings, engines, shelters, guns, and vehicles. The type numbers designate the uncoated cloth to be used, and the class numbers designate the kind of coating. Type I uncoated cloth is about half the weight of type II. Class 1: coating of chloroprene rubber; class 2: coating of a virgin polymer or copolymer of vinyl chloride resin (to contain an evenly dispersed fire inhibitor when used on type II cloth); class 3: coating of chloroprene rubber containing an evenly dispersed fire inhibitor. The cloth is coated on both sides but not necessarily equally. The six kinds of product are specified as to weight, breaking strength, tearing strength, and stiffness, among other properties. The heaviest type I cloth can weigh as much as 11.5 ounces per square yard; the heaviest type II cloth, as much as 19.0 ounces per square yard. Color is apparently the option of the procuring agency.

Vinyl-coated (class 2) cloth is not suitable when the intended use involves flexing or folding at temperatures below 0°F. Chloroprene-coated (classes 1 and 3) cloth is suitable when the intended use involves flexing or folding at temperatures down to -40°F. Properly compounded vinyl coatings (all colors) but only the dark shades of neoprene (apparently classed as a chloroprene) are recommended for exposure to "natural weathering."

**CLOTH, Cotton, Airplane Curtain. MIL-C-9336(1) (USAF).** 1959 -- Flame-resistant mercerized cotton cloth intended to be used for aircraft Curtains. Color:Field Green, #34079 in Federal Standard NO. 595 -- sometimes called Shadow Green. The cloth can weigh from 6.00 to 6.50 ounces per square yard.

**CLOTH, Cotton, Netting. MIL-C-9278(USAF).** 1954 -- A conventional leno-weave cotton cloth dyed Interim Olive Drab (color #X34087 in Addendum of 2 of Federal Standard No. 595), intended for use in making protective covers for aircraft wings and stabilizers. Its weight is specified as 5±1 ounces per square yard, and it comes in rolls 25 to 100 yards in length and 42±1 inches in width.

**CLOTH, Osnaburg, Cotton. CCC-C-429b.** 1964 -- Osnaburg is a strong unbleached cotton fabric. It is ordinarily used as target cloth and for packaging and packing. Three classes are specified in terms of minimum weight, yarns per inch, and breaking strength. Class 2 weighs at least 6.8 ounces per square yard. class 3, at least 5.4 oz/sq yd; class 5, at least 3.9 oz/sq yd.

**NET, Camouflage, Fiber: Cotton. MIL-N-568C.** 1961 -- A net of Commercial No. 18 or No. 24 cotton seine twine woven in meshes approximately 2 1/4 inches square with all cords either parallel or perpendicular to the sides of the net. Seven customary sizes (all dimensions in feet): 14 X 29, 15 X 15, 17 X 35, 22 X 22, 29 X 29, 36 X 44, 45 X 45. (But any size can be specified by the procuring agency.) Color to be neither lighter than #34127 (a dark olive green) nor darker than #X34087 (Interim Olive Drab) of Federal Standard No. 595.

**NET, Camouflage, Fiber, Cotton-Twine, with Hardware and Fabric Garnishment, for Drape Sets. MIL-N-11849B(1).** 1960 -- These specifications prescribe how cotton-twine camouflage nets are to be joined for certain uses. Eight "styles" of camouflage net assemblies are covered: Style a -- four nets, all 36' X 44', for Camouflage Net Set, Field Artillery; Drape, 72 ft w, 88 ft lg. Style b -- four nets, all 29' X 29', for Camouflage Net Set, Field Artillery; Drape, 58 ft w, 58 ft lg. Style c -- four nets, all 22' X 22', for Camouflage Net Set, Anti-Aircraft Gun; Drape, 44ft w, 44 ft lg. Style d -- two nets, both 17' X 35', for Camouflage Net Set, Anti-Aircraft Machine Gun; Drape, 34 ft w, 35 ft lg. Style e -- four nets, all 45' X 45', for Camouflage Net Set, Field Artillery; Drape, 90 ft w, 90 ft lg; and eight nets, same size, for Camouflage Net Set, Guided Missile Artillery Launching Site; Drape, 90 ft w, 180 ft lg. Style f -- apparently 18 nets, all 14' X 29', for Camouflage Net Set, Field Artillery; Drape, 90 ft w, 90 ft lg. Style g --

apparently nine sets, all 29' X 29', for Camouflage Net Set, Field Artillery; Drape, 90 ft w, 90 ft lg. Style h -- eight nets, all 45' X 45', for Camouflage Net Set, Guided Missile Artillery Launching Site; Drape, 90 ft w, 180 ft lg. The nets themselves conform to specifications MIL-N-763 (Net, Camouflage, Fiber, Garnished with Fabric, Flat Top andDrape Patterns), except that the garnishing is prescribed in separate drawings. The size of cotton seine twine used for style a, b, e, and h nets is commercial No. 24; the size for styles c, d, f, and g, No. 18.

NET, Camouflage, Fiber, Garnished with Fabric, Flat Top and Drape Patterns. MIL-N-763B(2). 1960 -- Finished camouflage nets made from cotton twine nets garnished with strips (garlands) of impregnated camouflage cloth (MIL-C-765), presumably type II (burlap), intended to be used in camouflaging vehicles, weapons, observation posts, and other small equipment and installations when used single, and in camouflaging large gun emplacements of other installations when two or more nets are joined to make a net set.

The strips of impregnated camouflage cloth, two inches wide by 60 inces long, are woven into the net by inserting each strip alternately over and under the meshes of the net. They arenot woven diagonal. All turns are at right angles. The strips are kept flat, and each covers from 18 to 20 meshes of a 2 1/4-inch-mesh net. The ends of each strip are secured to the net with an overhand knot. The knot is tied tight, leaving a 1 1/2- to 3-inch free end sticking out (Irish pennant), which is not to be trimmed or cut off. Knots are not tied to the taped edges of the net or to gun slits. The garnishing is not drawn tight but contains enough slack to prevent distortion of the mesh and so that the net may take all the strain when set up. The garlands do not cross over one another. The strips nearest the edges of the net terminate at right angles to the nearest edge.

The drape pattern of garnishing comprises a completely garnished ("100%") central area surrounded by a gradual thinning out of the garnishing carried to the edge of the net. (The effect of irregularity is achieved when the net or net set is draped.) The flat-top pattern of garnishing is of an irregular shape comprising a completely garnished central area surrounded by a gradually thinned-out region terminating in an irregual outline. A set of two or more nets is garnished as a whole.

Garlands of two or three colors are blended in the net, there being four schemes, as follows. The color names and numbers are those set forth in specifications MIL-C-675 (Cloth, Camouflage, Flame Resistant: Osnaburg and Burlap; 100-Yard Rolls). Summer: dark green (color No. 2), 70%; field drab (No. 4), 15%; light green (1), 15%. Winter: earth brown (5), 60%; earth red (8), 10%; olive drab (9), 30%. Desert: sand (3), 80%; olive drab (9), 10%; light green (1), 10%. All-seasonal: dark green (2), 60%; earth brown (5), 40%. The garlands are woven into the net to make an even mixture of colors. Long, straight runs, patterns, or areas of one color are unsuitable. When the foregoing prescriptions are followed, it is found that the number of 60" X 2" garlands required for the several sizes of net are as follows. Drape: for 22' X 22' nets, 430 strips; for 29' X 29' nets, 760 strips; 36' X 44', 1470; 45 X 45, 1975. Flat top: for 15' X 15' nets, 125 strips; for 22' X 22' nets, 250 strips; 14' X 29', 220; 29' X 29', 425; 17' X 35', 300; 36' X 44', 775.

NET, Multipurpose. MIL-N-43181(2). 1966 -- Intended to meet multiple requirements of Special Warfare units, as a hammock, camouflage net, carrier for bulky loads, litter, or for fishing or catching game. Of multi-filament nylon yarn, knit with a mesh size of 9/16" by 9/16" (inside measurements) ±1/16", dyed to make the color of the finished net "Olive Green 106." Width, about 56"; length, at least 108".

NETTING, Camouflage, Wire, Steel, Fabric-Garnished. MIL-N-52136. 1960 -- The wire netting can be that of specifications MIL-N-586 (Netting, Camouflage, Wire, Steel, Straight-Line Woven, Zinc-Coated) or MIL-W-585 (Wire Fabric, Steel, Welded), type II, except that the nominal mesh size is either 2" X 21/2" or 2 5/8. The garnishing material is the 2-inch-wide stripping specified in MIL-C-765 (Cloth, Camouflage: Impregnated, Flame-Resistant; Osnaburg and Burlap; 100-Yard Rolls), presumably type II (burlap). On one side of the wire netting, the garnishing strips are laid out flat and parallel to the warp (longitudinal), their center lines 6 inches apart. These strips are part of the camouflage and also serve as base for the garnishing on the other side of the wire netting: each strip, also laid flat, passes diagonally back and forth every 6 inches between two of the longitudinal strips of the other side, being stapled to the latter where they overlap.

The finished camouflage netting comes in rolls 6 feet wide and (normally,unless otherwise specified) 150 feet long.

NETTING, Camouflage, Wire, Steel, Feather-Garnished. MIL-N-52095(1). 1963 -- The netting is zinc-coated one-inch-hexagonal-mesh poultry netting (chicken wire?), the wire nominally 0.0348 inch in diameter before coating. The garnishing is body feathers from chickens or turkeys "glued" to the netting prior to painting, with 1 1/2 to 2 ounces of dry feathers per yard of wire netting, of uniform visual distribution.
The garnished netting comes roller- or dip-painted in the standard colors listed in the accompanying table. It is furnished in rolls 6 feet wide and (unless otherwise specified by the purchasing agent) 75 feet long.

NETTING, Camouflage, Wire, Steel, Glass-Fiber Garnished. MIL-N-52154(1). 1963 -- Wire netting garnished with highly flexible staple (short-fiber) glass-fiber yarn. The glass fiber is sandwiched between three layers of wire netting, the base layer, in the center, being wire conforming to specifications MIL-N-586 (Netting, Camouflage, Wire, Steel, Straight-Line Woven, Zinc Coated), wire size optional, or to specifications MIL-W-585 (Wire, Fabric, Steel, Welded), type II, mesh size 2" X 2 5/8"; and two over-lays, one on each side of the base layer, of zinc-coated poultry netting (chicken wire?) -- all fastened together by wire or otherwise to prevent shifting of the glass fiber held in between. The wire size of the poultry netting is 0.0348 or 0.0410 inch before zinc-coating. The garnishing is to be of uniform visual distribution, between 2 and 3 ounces of (unpainted) fiber per square yard of netting.
The garnished netting is furnished in rolls 6 feet wide and (unless otherwise specified by the purchasing agent) 75 feet long. It is roller- or dip-painted in the standard colors listed in the table accompanying the description (above) of Netting, Camouflage, Wire, Steel, Feather-Garnished (MIL-N-52095).

NETTING, Camouflage, Wire, Steel, Steel-Wool Garnished. MIL-N-52135 (1). 1963 -- Strands of steel-wool batting, approximately 4 inches wide, laid out over, and stapled to, 2- by 6-inch-mesh welded wire netting (MIL-W-585), parallel to the long side of the mesh. There is to be at least 12 ounces of steel wool per square yard of netting, of uniform distribution.

## INFRARED REFLECTANCE SPECIFICATIONS
## FOR
## NETTING, CAMOUFLAGE, WIRE, STEEL, FEATHER-
## GARNISHED, MIL-N-52095

| Color and Color Number (Federal Standard No. 595) | | Infrared Reflectance* Minimum (%) | Maximum (%) |
|---|---|---|---|
| White | 37875 | 57.0 | 100.0 |
| Black | 37038 | 0.0 | 24.5 |
| Earth Brown | 30099 | 24.5 | 57.0 |
| Field Drab | 30118 | 24.5 | 57.0 |
| Earth Yellow | 30257 | 24.5 | 100.0 |
| Sand | 30277 | 24.5 | 100.0 |
| Earth Red | 30117 | 24.5 | 57.0 |
| Desert Sand | 30279 | 24.5 | 100.0 |
| Forest Green | 34079 | 24.5 | 57.0 |
| Dark Green | 34102 | 37.0 | 57.0 |
| Olive Drab | 34087 | 24.5 | 57.0 |
| Light Green | 34151 | 37.0 | 57.0 |

*Before and after accelerated weathering.

The garnished netting is furnished in rolls 6 feet wide by 75 feet long, unless the length is specified otherwise by the purchasing agency. It is painted in the standard colors listed in the table accompanying the description (above) of Netting, Camouflage, Wire, Steel, Feather-Garnished (MIL-N-52095).

NETTING, Camouflage, Wire, Steel, Straight-Line Woven, Zinc-Coated. MIL-N- 586B 1964 -- Intended for use as a base for garnished camouflage netting. The mesh consists of a warp of parallel strands of wire 2±1/4 inches apart and a filler of the same size wire woven diagonally back and forth between adjacent strands of warp, secured every 2±1/4 inches to the latter by twisting around 2 to 4 turns in a conventional or reverse twist. The wire is carbon-steel wire of nominal diameter 0.0348 or 0.0410 inch. The netting is furnished in rolls 6 feet wide and 150 feet long, unless otherwise specified by the purchasing agency.

## 2. COATINGS INTENDED SPECIFICALLY FOR CAMOUFLAGE USE

DOPE; Celluose-Acetate-Butyrate, Pigmented, Camouflage. MIL-D-5550A (1). 1951 -- Intended for use as the top coat on aircraft fabric surfaces for obtaining a camouflage finish. Colors of interest to the land Camoufleur: Insignia White (601 in ANA Bulletin NO. 157), Black (604), Medium Green (612), Olive Drab (613), Orange Yellow (614), Middlestone (615), Sand (616), Dark Earth (617), Dull Red (618). Minimum admissible weight of the liquid dope is 7.6 pounds per gallon. The prescribed thinner is Thinner, Celluose Acetate Butyrate Dope (MIL-T-6096A).

DOPE; Celluose Nitrate, Pigmented, Camouflage, MIL-D-5555 (1). 1955 -- For use on aircraft fabric surfaces (excepting rubberized fabric). Some of the colors: Insignia White (601) in ANA Bulletin No. (157), Black (604), Medium Green (612), Olive Drab (613), Orange Yellow (614), Middlestone (615), Sand (616), Dark Earth (617), Dull Red (618).

ENAMEL, Camouflage, Quick Drying. MII-E-5556B (2). 1965. -- A quick-drying, flat, semi-gloss alkyd aircraft enamel intended primarily for spray application. For use on

metal parts and surfaces as a camouflage color finish over aircraft zinc chromate primer. Some of the colors: Insignia White (37875 in Federal Standard No. 595, as amended by Addendum No. 2), Black (37038), Interior Green (34151), Medium Green (34092) Olive Drab (X34087), Orange Yellow (33538), Dark Earth (30118), Brown (30117, elsewhere called Earth Red). But the enamel may be pigmented in any color. The pigmentation and the applicable qualitative and quantitative requirements are to conform to those of the nearest matching color in the specifications. Storage stability: one year in a full, closed container under warehouse storage conditions at 70° to 90° F. Primer: Primer Coating, Zinc Chromate, Low-Moisture-Sensitivity (MIL-P-8585). Thinning for spraying: with aromatic petroleum naphtha (Naphtha, Armomatic, TT-N-97B), the dilution to be no greater than 1 volume of thinner to 4 volumes of enamel. Thinning for brush application: with mineral spirits (Thinner; Paint. Volatile Mineral Spirits (Petroleum Spirits), TT-T-291).

ENAMEL, Camouflage, Solar-and Heat-Reflecting. MIL-E-46061 (1). 1964. -- A quick-drying synthetic solar- and heat-reflecting camouflage enamel. To be used as a tone-down camouflage enamel on missile components which when subjected to radiation tend to be damaged by excessive absorption of heat. To be applied over a white lusterless enamel (Enamel, Lusterless, Quick Drying, MIL-E-10687;cancelled). Color: a lusterless dark green. Will resist lubricants and oils commonly used on missile systems. Storage stability: 6 months in a full, closed container at 70° to 90°F.

LACQUER: Acrylic-Nitrocellulose, Camouflage (for Aircraft Use). MIL-L-19538B (ASG). 1963. -- For use as a general-purpose exterior coating for metal surfaces; particularly formulated for resistance to diester lubricating oil. Primarily for spraying. Intended to be used only over a system consisting of wash primer (Coating Compound, Metal-Pretreatment, Resin-Acid, MIL-C-8514) and lacquer type primer (Primer Coating, Celluose-Nitrate Modified Alkyd Type, Corrosion-Inhibiting, Fast-Drying, etc, MIL-P-7962B). Does not adhere well over zinc chromate primer. Exhibits excellent adhesion to celluose nitrate camouflage lacquer (Lacquer, Camouflage, TT-L-20). Thinner: Thinner, Acrylic-Nitrocellulose Lacquer, MIL-T-19544B. Two coats required when sprayed. Drying time: no more than 40 minutes uder specified drying conditions. Storage stability: to

retain all characteristics except weatherability after storage for one year at 70° to 90° F. The foregoing does not include the changes effected in the 1964 amendment.

LACQUER CAMOUFLAGE. TT-L-20. 1963.-- Replaces Lacquer, Camouflage (MIL-L-6805). For use on metal surfaces as a camouflage colorfinish. Some of the colors: Instrument Black (514 in ANA Bulletin No. 157), Insignia White (37875 in Federal Standard No. 595), Black (37038), Interior Green (34151), Medium Green (612), Olive Drab (613), Orange Yellow (33538), Middlestone (30266), Dark Earth (617). Minimum weight per gallon: black, 7.5 lb; all other colors, 8.0 lb. Thinner: Thinner, Dope and Lacquer (Celluose Nitrate), TT-T-266B. Thinning the lacquer with an approximately equal amount of thinner will generally be satisfactory for spraying and brushing, it seems. Best results are obtained when applied over a zinc chromate primer (Primer Coating, Zinc Chromate, Low-Moisture-Sensitibity, MIL-P-8585) over a pre-treatment coating (Coating Compound, Metal Pretreatment, Resin-Acid, MIL-C-8514). Satisfactory results can be obtained with the pre-treatment coating plus a lacquer-type primer (Primer Coating, Cellulose-Nitrate Modified Alkyd Type, Corrosion Inhibiting, Fast Drying, etc, MIL-P-7962).

PAINT, Temporary, Lusterless, Gasoline Removable. MIL-P-13983C (1). 1962.-- Intended primarily for brush application for temporary blackout and camouflage purposes at below-freezing temperatures and when camouflage or identification markings must be removale. Some of the colors: Earth Brown (30099 in Federal Standard No. 595 as amended by Addendum No. 2), Dull Red (30109), Maroon (30111), Earth Red (30117), Field Drab (30118), Earth Yellow (30257), Sand (30277), Desert Sand (30279), Forest Green (30749), Olive Drab (X34087), Dark Green (34102), Green (34108), Light Green (34151), Lusterless Green (34258), Black (37038), Lusterless White (37875, usually called Insignia White). Paraffin vehicle. Thinner: mineral spirits (Thinner; Paint, Volatile Spirits (Petroleum-Spirits), TT-T-219c) or gasoline for brush application.

PAINT, Temporary Identification, Camouflage. MIL-P-6884B. 1960.-- Intended for use as camouflage temporary identification paint over finisher of gloss lacquer (Lacquer, Acrylic-Nitrocellulose Gloss (for Aircraft Use), MIL-L-19537C); gloss enamel (Enamel, Gloss, MIL-E-7729B), camouflage lacquer (Lacquer, Camouflage, MIL-L-6805, which

has been replaced by Camouflage Lacquer, TT-L-20; Lacquer: Acrylic-Nitrocellulose, Camouflage (for Aircraft Use), MIL-L-19538B), or camouflage enamel (Enamel, Camouflage, Quick Drying, MIL-E-5556B). To be removable after an extended weathering period, with mineral spirits or any other predominantly aliphatic solvent, like gasoline, without impairing the permanent finish. Some of the colors: Medium Green (612 in ANA Bulletin No. 157), Olive Drab (613), Desert Drab (628), Light Green (630), Shadow Green (631), Insignia White (37875 in Fed. Std. No. 595), Black (37038), Lusterless Green (34079), Orange Yellow (33538). For brushing and spraying. Thinner: aromatic naphtha (Naphtha; Petroleum; Aromatic (for Use in Organic Coatings), TT-N-97B) type I, grade B. Drying time: 1 hour.

PAINT, Water, Paste (for Camouflage Use). MIL-P-13340A. 1962. -- An oil-in-water past emulsifiable with water and miscible with gasoline. Colors: Light Green, Dark Green, Sand, Field Drab, Earth Brown, Earth Yellow, Earth Red, Olive Drab, Frest Green, Desert Sand, Black, White, all specified in an accompanying chromaticity diagram.

Suitable for application to wood or metal surfaces when diluted with gasoline or water in a one-to-one ratio. Suitable for application to fabrics when diluted in the ratio of 1 part paste to 3 parts water by volume. Drying time: no more than 6 hours at 73.5±2°F at 50±5% relative humidity. Primer: presumably Primer Coating; Phenolic, Water Immersible (MIL-P-12742).

## 3. SOME COATINGS THAT MAY FIND USE IN CAMOUFLAGE WORK

COATING, Compound, Bituminous, Solvent, Coal Tar Base. MIL-C-18480A(DOCKS). 1961 -- A cold-applied coal-tar-base coating compound for use on steel structures under conditions where it is not feasible to use a hot-applied coal-tar enamel. A homogeneous mixture of coal-tar pitch, a solvent that readily blends the pitch, and an inert non-water-absorbing mineral filler. Adheres firmly to bare steel, primer, and itself. Drying time: 6 hours set to touch under prescribed conditions.

COATING COMPOUND, Bituminous, Emulsion Type, Coal Tar Base. MIL-C-15203C(DOCKS). 1962 -- Emulsified coal tar coating comound intended to be used as a protective coating over bituminous corrosion-mitigation systems subjected to atmospheric exposure by protecting against the deleterious effects of oxidation and ultra-violet radiation. Of such consistency as to be readily applicable either by brushing or spraying to dried bituminous protective coatings. Resistant to intermittent immersion in sea water.

COATING COMPOUND, Bituminous, Solvent (for Railway Rolling Stock). MIL-C-13950(CE). 1955 -- A bituminous coating compound intended for use as a protective coating on railway rolling stock. Type I: without sound-deadening properties; intended for use as a protective coating for roofs and underframes of such railway rolling stock as metal-roof-type box cars, freight cars, and refrigerator cars. Type II: with sound-deadening properties; intended for use as a protective coating and sound deadener for roofs of such railway rolling stock as kitchen and ambulance cars. Both types are mixtures of asphalts, fillers, solvents, and additives. The filler can be a combination of short asbestos fibers and mica or of asbestos fiber and cork. Weight per gallon: 8.0 to 10 lb. Sprayed at 60°to 140°F. Drying time: 4 hours, set to touch; 24 hours, practical hardness.

COATING COMPOUND. Luminescent, Phosphorescent. MIL-C-4996A(ASG). 1961 -- A pale-green ("Color No. 61") non-radioactive phosphorescent coating compound, visible in the dark from excitation by ultra-violet radiation of 365 mu wavelength, and luminescent for a while after removal of the excitation. Intended for use in marking dials to be read when excited by ultra-violet radiation, as well as to be legible on a black background in the daytime. For use on non-combat watches, tail-turret azimuth indicators, and other markings and dials requiting a long afterglow but where the exposed situation of the instrument preclude the use of radioactive material. Dominant wavelength of the fluorescence, 547 mu (with a minimum of 80 effective microlamberts luminance); dominant wavelength for reflection, 550 mu (reflectance, 70%). Type I -- Compound Form: a powder with separate adhesive and thinner, a liquid mixture and thinner, or a liquid mixture ready for application. Type II — Applied Form: a uniform layer in or on a paper, plastic, cloth, or metal

support.
Drying time: 4 hours when dried according to instructions Life-time of phosphorescence: 50 seconds to 5% of the luminance under the exciting radiation. Heat resistance: to resist baking for 20 hours at 194±9°F.

**ENAMEL, Textured, Olive Green (for Coating Liners, Hamlet M-1) MIL-E-2052A. 1963** -- An alkyd-type lusterless textured enamel for use as a finishing on plastic (phenolic) helmet liners by brush or spray application. Class 1 textured enamel is an air-drying enamel to be used for re-coating. Class 2 textured enamel is a baking enamel to be used for initial coating or re-coating. Drying time for Class 1: set to touch,20 minutes; dry hard, 2 hours; full hardness, 48 hours. Color: 10Y3/3 in Munsell system.

**LACQUER, Lusterless, Obliterating. TT-L-40. 1959** --
A quick-drying lusteless lacquer for obliterating purposes. Intended to obliterate old markings, mismarkings, and for use as an undercoating for marking on shipping containers. Colors for which the specifications were mainly devised: 30277 (Sand), 30372 (a color close to Sand but lighter). 33531 (which looks like an almost completely washed out orange-yellow; lighter than the other two specified colors). (The five-digit numbers are the designations in Federal Standard No. 595 (1956).) None of these colors comes even close to any of the standard ANA 157e aircraft camouflage colors. The first (30277) is apparently intended to be the most often used color for this lacquer. Any of the three might serve as a camouflage lacquer in a pinch. Field-expedient pigments might improve the hue but of course should be added only under advisement. Dry-through time: no more than 5 minutes.

**LACQUER, Multicolor, Aqueous, Dispersion Type (for Spray Application). TT-L-45b. 1959** -- Despersions of pigmented aqueous nitrocellulose lacquer suitable for spray application. The dispersion consists of a continuous water phase containing methyl cellulose and other suitable stabilizers and one or more pigmented lacquer phase Devised for producing a mottled effect (spatter coating), but can be pigmented in only one color if desired. Intended for use on both interior (type I) and exterior (tyoe II) surfaces. Substrates: the usual building materials: wood, masonry, plaster, wallboard, etc. Type II (exterior) can also be used in-doors. To be applied

with conventional air gun to obtain the desired pattern and texture. Brushing, roller-coating, etc. not satisfactory. Pressure-type guns strongly preferred to siphon-type guns. Thinning: Not ordinarily advisable, but water can be used, if sparingly. Comment: has possibilities for camouflage against close-up observation.

LUMINESCENT MATERIAL, Fluorescent. MIL-L-25142(ASG). 1955 -- Intended for use on interior markings of aircraft -- such as on instrument dials, control panels, and instruction panels -- to permit the markings to be read in the dark when excited by ultra-violet radiation, as well as to be legible in the daytime. Emission to be excited by radiation of about 365 mu; to cease almost immediately upon removal of the excitation (which characteristic distinguishes fluorescence from phosphorescence, both being kinds of luminescence). Type I -- compound form for brush application: for use in depots, repair shops, etc; can be supplied as a powder with separate adhesive and thinner, as a liquid mixture with separate thinner, or as a liquid mixture for direct application; 4 hours for drying hard. Type II -- applied form: all products to which fluorescent material has been applied; furnished as a uniform layer in or on a paper, plastic, cloth, or metal support, such as an instrument dial or pointer; includes dials, switches, controls, and identification and instruction panels that are purchased with the fluorescent material already applied. Type III -- compound form for screen application: for use in depots, repair shops, etc; can be supplied as a powder with separate adhesive and thinner or as a liquid mixture with separate thinner: 24 hours for drying hard. Type IV -- transfer form: all products in the form of decalcomania and pressure-sensitive-adhesive-coated materials to which the fluorescent material has been applied; water resistant.
Dominant wavelength of the fluorescence: 588 mu (with at least 25 effective microlamberts luminance); dominant wavelength for reflection: 575 mu (reflectance, 68%).
Emmision to decay to no more than 10% within 1/2 second after removal of excitation.
Heat resistance: to resist baking for 20 hours at 194±9°F.

LUMINESCENT MATERIAL AND EQUIPMENT, (Nonradioactive). MIL-L-3891 (with Ament 2). 1961 -- For operational military uses. Can be supplied in 2 types, 5 forms, and various shapes and colors.
Type P -- phosphorescent: Emitted light decays from at least 24 equivalent microlamberts, 2 minutes after removal of exciting radiation, to at least 0.15 equivalent microlamberts, 6 hours after removal of exiting radiation. Daylight colors range between white and greenish yellow. Used where luminosity is to persist, after removal of the exciting radiation, as much as 8 hours after the observer's eye become well dark-adapted. Not suited for uses requiring observation before the eyes have been dark-adapted less than 20 minutes.
Type F -- fluorescent: Colors of fluorescence: blue, green red, orange, yellow. Requires special ultra-violet lighting equipment. Also intended for daytime use where greater luminance and contrast is required; in this case sunlight provides the ultra-violet exciting radiation.
Forms: liquid or paste (1); rigid-plastic-backed (2); flexible-plastic-backed (3); cloth (4); tape (5). Shapes: rectangular sheets, disks, irregular shapes, markings.
Exciting radiation: the range 326-402 mu of the near ultra-violet.
Heat resistance: not to deform, soften or flow after 24 hours at 50°C (122°F). Resistance to temperature change: not to crack, peel, or flake through expansion of the base material caused by rapid temperature changes between -40° and +120°F. Resistance to humidity: to adhere to the base surface after prolonged exposure to high-humidity air. Storage stability: to conform to specifications after 30 days on the shelf. Adhesive to be pressure-sensitive and suitable for application of the material at any temperature from 50° to 120°F.

MILDEW RESISTANT COMPOUND, Textile (for Field Retreatment) MIL-M-13295B. 1964 -- Two types of mildew-resistant compound for the re-treatment of textile fabrics, tentage, tarpaulins and equipage. Comes as pastes for mixing with petroleum solvent (Stoddard solvent or equivalent). Type I -- Mildew -, water-, weather-, and fire-resistant. Pigmented for #34087 (olive Drab) in Federal Standard No. 595 (apparently not amended). For re-treatment of tentage and tarpaulins ("paulins"). Diluted with an equal

volume of solvent. One gallon is sufficient to cover 10 square yards. Type II -- Mildew- and water-resistant. Not pigmented. For re-treatment of equipage, lightweight tentage, and fabric. Diluted in a ratio of 1 part by volume of the concentrate with 16 parts by volume of solvent. Can be applied by spraying, brushing, or immersion. One gallon of the diluted compound will cover 8 square yards of fabric.

PAINT, (Outside, Dull Black Formula No. 104). MIL-P-15146A. 1951 -- For use on the exterior of surface vessels. Weight per gallon: 9.0 to 9.6 lb. Time for setting to touch: 1 hr. Time for drying hard: 5 hr.

PAINT, Heat-Resisting, Olive Drab (for Steel Surfaces). MIL-P-14105A(CE). 1956 -- Intended for use on sand-blasted and solvent-degreased steel surfaces of components which are subject to temperatures as high as 1400°F and exterior weathering. Can be used on mufflers, manifolds, stacks, etc. Provides excellent protection against corrosion and chemical attack, after drying and during and after curing. May be applied, air-dried, and cured while the equipment is in operation. Can be applied by spraying, brushing, or dipping. Performs satisfactorily even when applied to surfaces that do not lend themselves to sand blasting. Color: #3412 in Specifications TT-C-595 (superseded), Olive Drab, corresponding to X34087 in Federal Standard NO. 595 (Addendum No. 2). Minimum weight per gallon: 11.0 lb. Drying time: tackfree within 1 hour of application on steel

PAINT, Phosphorescent, Ready-Mixed (Non-Radioactive). TT-P-54a. 1956 -- For use as marker, indicators, etc. in non-operational military and other application. Type I: high initial brightness, short afterglow; suitable only for in-door use. Type II: low initial brightness, long afterglow; may be used for either in-door or out-door use. Primer: a white-lead-free primer or under-coat with a spreading rate of about 175 square feet per gallon. Enamel, Interior, Undercoat, Tints or White (TT-E-543A) should be suitable for most in-door and out-door uses. Protective top coat: Varnish, Spar, Alkyd-Resin (TT-V-109) is suggested as suitable. Phos-phorescent color: type I, yellow-green; type II, blue to blue-green when observed in a dark room immediately after activation.

Non-radioactive phosphorescent paint is defined as a paint which, after exposure to a source of radiant energy, either visible or invisible, will continue to emit visible radiation for an appreciable period after excitation of the paint ceases. High-initial-brightness phosphorescent paint is defined as phosphorescent paint which has a comparatively high brightnews for a relatively short period (approximately 30 minutes) after excitation ceases. High initial brightness ordinarily is obtainable only in combination with a rapid rate of brightness decay, which results in reduction of the absolute brightness below useful levels within about an hour. Low-initial-brightness phosphorescent paint is defined as phosphorescent paint which has a useful afterglow lasting several hours. It has a lower initial brightness and longer effective afterglow than high-ititial-brightness paint.

PAINT, Traffic; Reflectorized for Airfield Runway Marking (Drop-In Type). TT-P-85b (Int. Amd. 3). 1964 -- Consists of a binder pigmented either white or yellow and one of the two types of relecting objects: Type I -- Granules, Reflectorized, TT-G-00490a; 1.7 pounds per gallon of binder. Type II -- glass spheres; 10 pounds per gallon of binder. Coverage: 110 to 120 square feet per gallon of binder. Weight per gallon of pigmented binder: white, 11.3 lb; yellow, 11.5 lb.

PAINT, Traffic Black (Nonreflectorized). TT-P-110b (Int. Amd. 1). 1966 -- A black non-reflectorized traffic paint for marking runways and highways. A ready-mixed paint in a one-package system. Intended for use on concrete, bituminous, brick, or stone surfaces of highways, bridges, tunnels, or parking lots, applied at a wet-film thickness of 16 mils by means of conventional traffic line stripping equipment. It may be used as an obliterating paint, for painting out white and yellow markings to permit marking in a different way. Dries to a smooth, uniform finish. Type I: vinyl toluene -- butadiene type; appropriate where a long drying time can be tolerated. Type II: chlorinated rubber -- alkyd type; appropriate where a short drying time is required. Thinner for Type I: V, M, and P naphtha solvent. Color: 37038 (lusterless Black) in Federal Standard NO. 595. Storage stability:

6 months from date of delivery in a full, tightly-covered container. Weight per gallon: 10.6 to 11 lb. for Type I; 10.2 to 10.6 lb. for Type II.

PAINT, Water Emulsion Type (for Stenciling and Obliterating). MIL-P-52108A(MR). 1965 -- Water emulsion paint for stencilling, for obliterating markings, and for service-color markings on wood and fiberboard containers. Colors: Sand, #30277 in Federal Standard No. 595; Yellow, 33538 (called Orange-Yellow in ANA Bulletin No. 157e); Black, 37038; Insignia White, 37875. Drying time: 60 minutes maximum, for air-drying, dry through.

PAINT SYSTEM, Fluorescent, for Aircraft Application. MIL-P-21563B(ASG). 1962 -- A high-visibility, durable, exterior, fluorescent paint system, consisting of a pigmented paint and a clear overlay lacquer containing a weathering stabilizer. Colors: red-orange (dominant wavelength about 610 mu); yellow-orange (dominant wavelength about 600 mu). Storage stability: to conform to the specifications after storage for one year in a full, closed container at 70° to 90° F. Thinner for spraying: toluene or xylene for both paint and clear lacquer. Both can be thinned with as much as an equal volume of thinner.

PRIMER COATING, Alkyd, Wood and Ferrous Metal. TT-P-636c (Amendment 1). 1963 -- A combination air-drying and -baking, oil-modified resin primer. Intended for priming the clean, rust-free, bare, or phosphate-treated ferrous metal parts of vehicles, guns, gun mounts, tanks, metal shipping containers, and similar ordnance materiel. Can also be used as a sealing undercoat on the wood parts of motor vehicles. Has good adhesion, flexibility, and durability, covers well, and hides in one coat. Shows good resistance to weathering, although it is contemplated that it will be covered with a suitable topcoat. Color: characteristic of red or brown iron oxide pigments. Drying time: set to touch, 15 to 60 minutes; dry through, 18 hours; full hardness, 72 hours.

## 4. SPECIAL EQUIPMENT FOR COATING

SPRAY OUTFIT, Paint, Portable, Power Driven, Cart Mounted with Compressor. MIL-S-45834(CE). 1959 -- A portable, self-contained unit suitable for spraying cold-water paint, non-fibrous emulsions, cut-backs, and enamels for camouflage purposes. Consists primarily of a cart-mounted, gasoline-driven air-compressor unit and a chest containing 2 pressure tanks, 2 spray guns, 2 pressure cups, 1 spray-gun extension handle, 2 respirators, and all hose, couplings, valves, gauges, and other necessary equipment. Coverage rate: at least 3000 square feet per hour per spray gun. Three nozzles: one for fluids and two for atomizing: one for internal and one for external mixing.

SPRAY OUTFIT, Paint; Bituminous Emulsion, Trailer-Mounted, with Compressor and Gasoline Engine. MIL-S-3050B. 1962 -- A complete, self-contained trailer-mounted spray outfit for spraying bituminous emulsions and other liquids from a standard 55-gallon shipping drum. Components: a four-wheel, rubber-tired, tow-type trailer; gasoline engine; air-compressor; material straining chamber; siphon tube; steel drum for sprayable material; two spray guns. Sprays paint, asphalt cut-back, bituminous emulsion, weed killer, insecticide, and disinfectant directly from the shipping drum. Gasoline engine 1/2 hp in specifications, but other sizes can be substituted.

SPRAY OUTFIT, Paint -- Gasoline Engine Driven -- Hand Truck Mounted (Trailer and Wheelbarrow Types). MIL-S-18643A. 1961 -- Intended for general shop and field material-spraying applications where a source of compressed air is not readily available. Essential components: gasoline-engine-driven compressor and air receiver suitably mounted either on a four-wheel trailer or on a wheelbarrow-type hand truck; pressure tank(s); spray guns; air and material hose assemblies; respirators. Type 1 -- Hand Truck, Trailer Type: size 1: compressor capacity, 15 cfm at 80 psig; size 2: compressor capacity, 30 cfm at 80 psig. Type 2 -- Hand Truck,

Wheelbarrow Type: size 1: compressor capacity, 15 cfm at 80 psig.

SPRAYER, Emulsion, Drum Mounting. MIL-S-23436(DOCKS). 1962 -- A portable, base-mounted sprayer, for mounting on a 55-gallon drum and suitable for spraying curing emulsion on freshly poured concrete. Essential components: gasoline-engine-driven pump, agitator, suction hose, pressure hose, spray gun, base for mounting on a 55-gallon drum. Pumping rate: 4 gallons per minute at a minimum pressure of 100 psi.

## 5. DECOYS

SIMULATOR, Atomic Explosion, M142, Parts for and Loading, Assembling and Packing. MIL-S-46528B. 1963 -- Produces these effects: (1) a bright flash lasting at least 1.72 seconds; (2) a fireball with a minimum diameter of 11 feet; (3) a report of a least 122 db intensity 150 feet from the simulator; (4) a mushroom-shape smoke cloud with a minimum diameter of 95 feet and a minimum height of 130 feet, forming within 30 seconds after firing the simulator, the cloud persisting in any shape for at least 15 minutes after the formation of the mushroom cloud.

SOMULATOR, Gunfire, Small Arms. MIL-S-82328(ONR/NTDC). 1965 -- Charges of oxygen and propane are exploded to simulate the firing of a 30-caliber machine gun, firing 500±50 rounds per minute. Includes smoke generation equipment.

SIMULATOR, Gunflash, M110, Parts, and Loading, Assembly and Packing. MIL-S-20441A(1)(MU). 1966 -- Produces a bright yellow flash with a minimum length of 15 feet and a minimum diameter of 12 feet. The report is at least 120 db in intensity 25 feet from the simulator.

SIMULATOR, Machine-Gun Fire, and Simulator, Rifle Fire: .30 Caliber. MIL-S-52233(CE). 1962 -- Intended for use in simulating machine-gun (type I) or rifle (type II0 fire as air-drop deception devices. Designed to fire 18 rounds of 30-caliber ball ammunition in bursts (type I) or sporadically (type II), while descending by parachute and after landing. Equipped with an explosive charge for self-destruction after firing.

SIMULATOR, Projectile, Air Burst, M27A1B1, Parts, and Loading, Assembling, and Packing. MIL-S-20448A(2)(Ord). 1962 -- A smoke and sound simulator which can be projected off the ground from an M7 Granade Launcher.

SIMULATOR, Projectile, Air Burst, M74A1, Loading, Assembling, and Packing. MIL-S-20517C(1)(Ord). 1962 -- A flash and sound simulator designed to be fired from an M8 pyrotechnic pistol and to burst with a brilliant flash, a loud report, and a ball of smoke at a minimum horizontal distance of 100 feet away from, and a minimum height of 50 feet above, the pistol.

SIMULATOR, Projectile, Ground Burst, M115A2, Loading, Assembling and Packing. MIL-S-10058D(1)(MU) 1966 -- Fired by an igniter activated with a pull cord. Produces an audible whistle and a report, the latter at least 113 db in intensity 75 feet from the simulator. Time from initiation to explosion, at least 5 seconds.

SIMULATORS, Artillery, Mine, and Demolition Noise. MIL-S-82337(ONR/NTDC). 1965 -- Simulate the noise of artillery, mine, or demolition explosions by exploding charges of oxygen and propane. Type I: 115 volts, 60 cps ac (Device 17A1A); type II: 12 volts dc (Device 17A1B). Fire at a rate of 10±2 shots per minute. Reports are at least 140±10 db in intensity, measured 25 feet away.

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13. ABSTRACT

Results are presented of a survey of the state of the art of camouflage, comprising examination of literature on the subject and interviews with persons working in the field. The practice of camouflage is reviewed under seven headings: principles, location and natural cover, artificial cover, camouflage paints and coatings, decoys, fieldworks, and smoke. The report includes a list of applicable military specifications, abstracts of selected specifications, and has a comprehensive bibliography.

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